DOCUMENT RESUME

ED 151 180 SE 023 936

TITLE	Certification Training Manual for the Structural Pesticide Applicator.
INSTITUTION	Arizona Univ., Tucson. Cooperative Extension Service.; California State Polytechnic Coll., Pomona. Kellogg-Voorhis Campus.
SPONS AGENCY	Environmental Protection Agency, Washington, D. C.
PUB DATE	Apr 75
GRANT	EPA-68-01-2918
NOTE	190p.; For related document, see SE 023 937; Not available in hard copy due to marginal legibility of original document
EDRS PRICE	MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS	Certification; *Entomology; *Environmental Education; Equipment Standards; Federal Legislation; *Pesticides; Pollution; *Public Health; Safety
IDENTIFIERS	Labels

ABSTRACT

This manual is designed for use by commercial applicators preparing for certification in the use or supervision of the use of restricted pesticides especially in, on, or around food handling establishments, human dwellings, institutions, industries and any other structures and adjacent areas, public or private; and for the protection of stored, processed or manufactured products. Sections of the manual are concerned with entomology, labels and labeling, safety, equipment, fumigation and laws and regulations. (CS)

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CERTIFICATION TRAINING MANUAL

KW
Kellogg West

for the

STRUCTURAL PESTICIDE APPLICATOR

SE 023 936

COUNCIL FOR ENVIRONMENTAL STUDIES . COOPERATIVE EXTENSION SERVICE
COLLEGE OF AGRICULTURE . UNIVERSITY OF ARIZONA . TUCSON, ARIZONA

CERTIFICATION TRAINING MANUAL

for the

STRUCTURAL PESTICIDE APPLICATOR

This text is intended for use by commercial applicators to prepare for certification in the use or supervision of the use of restricted pesticides. It is designed for study by those applicators who will use or supervise the use of these pesticides in, on, or around food handling establishments, human dwellings, institutions such as schools and hospitals, industrial establishments, including warehouses and grain elevators, and any other structures and adjacent areas, public or private; and for the protection of stored, processed, or manufactured products.

Prepared by
Kellogg West, Center for Continuing Education
California State Polytechnic University, Pomona, California
Under Government Contract No. 68-01-2918
for the
Environmental Protection Agency

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College of Agriculture
University of Arizona
April 1975

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gerald R. Stairs, Director, Cooperative Extension Service, College of Agriculture, The University of Arizona, Tucson, Arizona.

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INTRODUCTION

In preparing the specifications for the acquisition of information to be included in this text I became aware of the fact that almost all of the books available on the subject of pest control are similar in one feature. They seem to favor a program of extensive reading, and the only method of study is reliance on extensive rote memory learning. I am not unmindful of the advantages that accrue to intensive reading. No one arrangement of material in a book can fit the arrangement needed by all levels of study of pesticide application. The material in this book is organized in such a manner that it is adaptable to more than one delivery system.

First the student is given a broad perspective of the common features of structural pests. Next, he is introduced to a field of study not heretofore included in most training programs. That is, the study of how pesticides can be applied in a manner that will not harm the environment, endanger the applicator, or present a hazard to human health.

In organizing this material I have attempted to group materials in such a manner that the instructor or the student can rearrange the order of presentation and assignments to fit changes in length of class hours or time allowed for home study.

Kellogg West, Center for Continuing Education, California State Polytechnic University administers a wide variety of courses in pest control operations. While there, I have had the opportunity to personally supervise the training and education of over a thousand students of pest control throughout the country. This includes, development of materials, creating format. classroom instruction and "on the job training." However this is my first opportunity to organize a program and develop materials that might have some value in home study. From my experience in adult education I have learned that adults assimilate information somewhat differently than the beginning student. However, one thing remains constant, that is the personal involvement of the student in advancing his education through student participation activities, problem solving and outside assignments.

As we approach the deadline for certification, there will be a last minute rush in the preparation of training materials. Remember, there are new areas of learning to be incorporated into our educational process. Most of us in the field of pest control education will not have had a long background of experience in this new and special approach to training. As time passes and changes in educational needs take shape, I would anticipate newer and better materials will be developed, which will be targeted to an educational process that is central to our needs.

Mandatory certification, although considered to be restrictive to some, may offer the pest control industry the greatest opportunity it has ever had to begin a nationwide program of reviewing old skills and acquiring new skills.

Eugene D. Young

EUGENE D. YOUNG
Project Manager

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FOREWORD

The purpose of the contract under which this book was designed is to develop a study of delivery systems for pesticide applicator training. Since the primary purpose of this training material is to enable the applicator to prepare for certification, it is not intended to be an in-depth study of all phases of pest control. Emphasis is placed on the broad general areas that should be covered to comply with the standards for determination of competency as set forth by E.P.A.

The mere presence of a few insects does not necessarily call for the routine application of pesticides. Therefore, throughout this text, recognition of the pest problem and correct diagnosis is stressed. Whenever a pest problem calls for the application of pesticides, the text provides for a complete understanding of pesticide safety, label comprehension, a knowledge of laws and regulations and an awareness of the effects of pesticides on the environment.

Many applicators have had considerable training and experience in the principles of pest control, and their competency in this respect will have been determined by licensing boards. However, there may be important differences between some state requirements, and the minimum standards as set forth by E.P.A. This text is intended to bridge that gap.

THE FOLLOWING PEOPLE HAVE CONTRIBUTED TO THE PREPARATION OF THIS BOOK, AND DESERVE RECOGNITION.

- **Edward W. Bushing**, Entomologist, Paramount Pest Control Service.
- **Kenneth Gordon**, Gordon Termite Control.
- **Dr. Kenneth P. Hobbs**, Bioecologist, Interdisciplinary Systems, Inc.
- **Dr. Richard Kaae**, Associate Professor, California State Polytechnic University.
- **George T. Okamura**, Chief, Laboratory Services, California State Department of Agriculture.
- **Henry G. Schierenberg**, Agricultural Biologist, California State Department of Agriculture.
- **Charles S. Papp**, Scientific Illustrator, Special Services, California State Department of Agriculture.

EDITED BY
DR. RICHARD KAAE
AND
EUGENE D. YOUNG

PROGRAM ADMINISTRATOR
GARY R. ENTWISTLE

PROJECT MANAGER
EUGENE D. YOUNG

INSECT DRAWINGS BY
CHARLES S. PAPP

DESIGN, PRODUCTION AND PRINTING BY
CENTURY ARTS, ARCADIA, CALIFORNIA

GENERAL ENTOMOLOGY

George T. Okumura
Chief Laboratory Services, California Dept. Food and Agriculture

Introduction

There are more kinds of insects on earth than all other living animals combined. Because of their adaptability, they are found in soil, water, snow, air and inside plants and animals. If it were not for the parasites, predators, diseases and occasional inclement weather to keep the population down, these pests would literally crowd us to death.

Some insects are so small that they are barely visible with the naked eye; while others in the tropical areas are huge with wingspans of almost a foot. However, the size of an insect is not always the true measure of its economic importance. For example, the human flea is so small that it is hardly seen by its victim. Yet this annoying creature can be a deadly messenger of a disease that is fatal to man.

For a control program to be most effective, the operator should know the identify of the insect involved. After recognizing the pest, one can research through literature to obtain needed information on its host range, habitat, the stage of its life cycle most susceptible to insecticides and even available means of control. This type of planning can be compared with an effective medical practice. The doctor must first recognize the organism that is causing the patient's illness before he recommends a pill.

Before identification of an insect is possible, one must first learn some basic knowledge of insect anatomy. This knowledge will also help the operator to apply the best method to control a pest. For example, the mouthparts of cockroaches and ants are structured for chewing; therefore, a poison bait is applicable in this instance. However, the same cannot be employed to control bed bugs who have mouthparts structured for piercing and sucking.

Economic Importance

Of the many creatures on earth, insects are the greatest competitor for human food and fiber. This fact has been proven by famine which has occurred from biblical times to this present age. The losses incurred to buildings, fresh agricultural crops, stored foods, forest trees, animals and fabrics by these everpresent creatures would no doubt ascend into many billions of dollars annually. Some insects are also harmful in that they are carriers of disease. Certain species of mosquitoes and fleas are carriers of malaria and bubonic plague respectively.

All insects are not harmful. In fact, insects are more beneficial than injurious in that the many of them are pollinators; some are parasitic or predaceous pests; and other produce materials that are useful to man. Honeybees produce honey and beeswax. Secretions from some insects are made into dyes and paints and silk comes from the cocoons of silkworms. The insects are food for birds, fish and other animals. The ever-decaying vegetation is assisted by these creatures to improve the soil that the humans must have in order to grow food.

External Anatomy

Man has a skeleton inside the body called a endoskeleton. The outer covering or skin of an insect is called an exoskeleton. This structure serves as a protective covering and a means of support. The exoskeleton restricts the growth of an insect; therefore, the insect must molt (shed its skin) in order to grow. This skin has a thin wax layer, which if damaged, causes the insect to die of dessication. Insecticides, such as silica aerogel, destroy the wax layer.

The body of an insect is divided into 3 regions, the head, thorax and abdomen (Fig. 1).

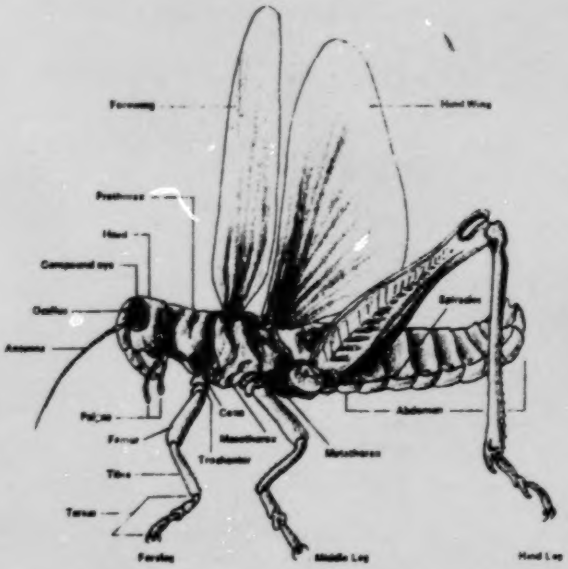


Figure 1 - General Structure of a Grasshopper

Head

Mouth parts, antennae, and the eyes are found on the head. There are 4 general types of mouth parts; chewing, piercing-sucking, sponging and siphoning. Chewing mouth parts are possessed by cockroaches, ants and beetles and used for cutting and grinding the food with their mandibles. Piercing-sucking mouth parts consist of a slender beak or proboscis which is used to puncture and suck the fluid from the host. Insects with these mouth parts are stable flies, bed bugs, conenose bugs, sucking lice and mosquitoes. Sponging mouth parts are comprised of a proboscis with a spongy tip to suck up liquid or soluable food. This type of mouth part is typical of flesh flies, blow flies and house flies. Siphoning mouth parts are formed into a long tube for sucking fluid which is common to moths and butterflies. In general, the organs of taste are located on the mouth parts.

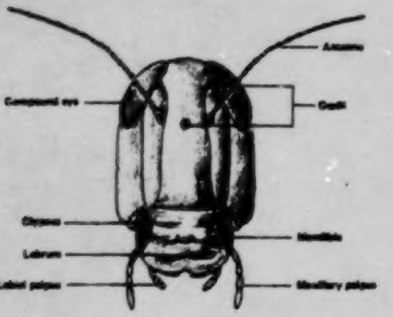


Figure 2 – Front View of a Grasshopper Head

Eyes: There are 2 types of eyes: compound and simple (Fig. 2). The simple eye is also called ocellus. It is small, possesses 1 lens, and can perceive only changes in light intensity. Vision as we know it is accomplished by the large compound eyes which possess many 6-sided lenses.

Antennae: One pair of antennae are present on the head. Antennae come in various shapes and sizes (Fig. 3). They are used as organs of smell by most insects and also organs of taste by Hymenoptera. Antennae are important to many insects who find their mates by odor. Artificial sex odors (pheromones) are used in traps and may soon be used for insect control.

Thorax

The thorax is divided into 3 parts: prothorax, mesothorax and metathorax. When 2 pairs of wings are present as in most insects, they are located on the mesothorax and metathorax; if only 1 pair is present as in the flies, they are on the mesothorax. Usually there are 2 pairs of spiracles (breathing holes) on the thorax; one between the prothorax and the mesothorax and the other between mesothorax and metathorax.

Wings: Wings are an outgrowth from the body wall (Fig. 4). In the flies that do have 1 pair of wings, the second pair is replaced by a pair of small knobs called halteres. The wings are given strength and support by the veins. The various sizes, shapes and textures of the wings and the pattern of the veins can be used in identification.

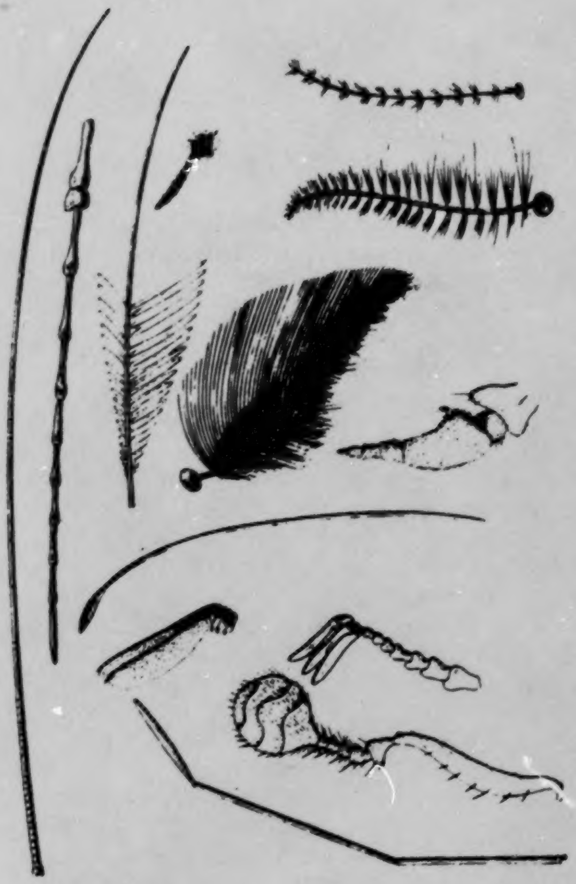


Figure 3 – Various Types of Insect Antennae

The forewings take many forms. In the beetles, they are hard shell-like; in the grasshoppers they are leathery; membranous in the flies; part hardened and part membranous in the true bugs (kissing bugs and grass bugs). The hindwings, are basically membranous for the majority of the insects. The forewings and hindwings of the moths and butterflies are both membranous but are covered with many scales.

Legs: Three pairs of legs are attached to the thorax, 1 pair each on the prothorax, mesothorax and metathorax. Insect legs vary tremendously in size and shape (Fig. 5) and are used in various ways depending on the insect. Some uses are for jumping, running, crawling, swimming, digging, food holding or mating. The parts or basic segments of the legs are the coxa, trochanter, femur, tibia and tarsus. The number of segments in the tarsus (plural: tarsi) is often used in identification.

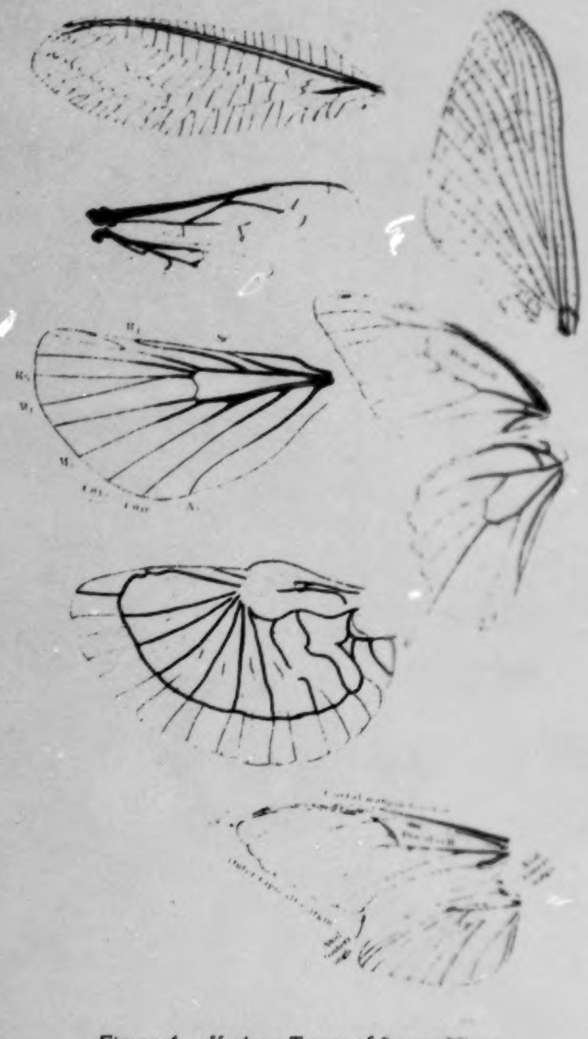


Figure 4 – Various Types of Insect Wings

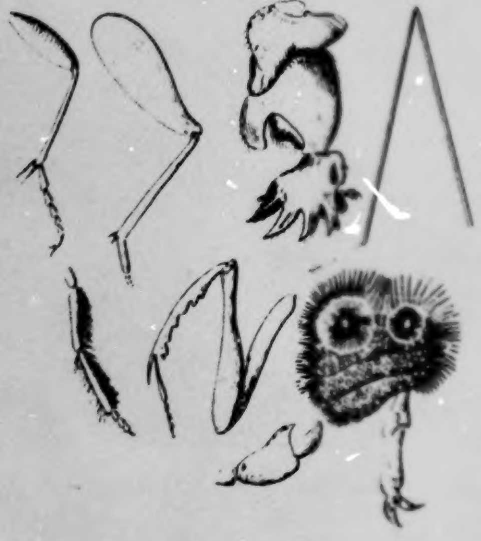


Figure 5 Various Types of Insect Legs

Abdomen

The abdomen is generally composed of 11 segments, but usually few are visible. On most of the segments are found hole-like openings on each side called spiracles through which the insect breathes. At the terminal part of the abdomen are found the external reproductive organs and, in some insects, tail-like appendages called cerci.

Internal Anatomy

The basic internal anatomy of a cockroach is presented in Figure 6. These structures may vary in size and shape depending on species.

Digestive System

Basically, the digestive system is a tube extending from the mouth to the anus. The tube is divided into 3 major parts; the foregut, midgut and hindgut. The food that is taken in at the mouth, passed through the esophagus (throat) and then into the crop where it is stored and where partial digestion may take place. Some insects posses a proventriculus (gizzard) where food is ground into finer particles. From here the food passes into the stomach where digestion and absorption takes place. The food then passes to the intestine where some absorption may occur and the undigested portion goes to the rectum and out through the anus.

Circulatory System

The circulatory system is very simple, consisting of a cylindrical tube extending from the posterior part of the abdomen to the head. The first half of the tube is called aorta and the other half the heart. The pulsation of the heart pushes the blood forward to the head where the blood is released into the body. The blood slowly flows backwards bathing the organs and is picked up by the ostia (tiny holes toward the rear of the heart) and circulation is repeated.

Excretory System

The waste from the body cells is absorbed by the blood. Then the waste from the blood is extracted by the malpighian tubules and discharged into the intestine near the junction of the midgut and the hindgut. The malpighian tubules and also the rectum function to extract water from waste in insects which live in dry foods.

Nervous System

In insects there are series of brains or nerve centers called ganglia. Two larger ganglia located in the head are connected by ventral nerve cords to smaller ganglia spaced at intervals to the end of the abdomen. The ganglia located in a segment are the nerve centers for that area. Most insecticides kill by disrupting the nervous system.

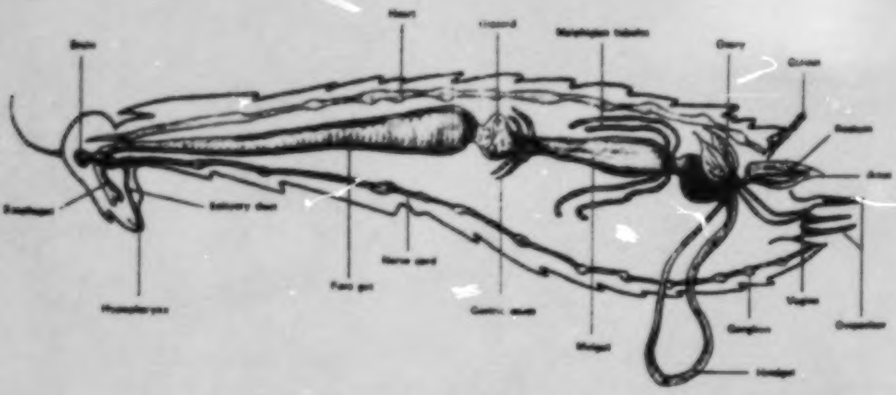


Figure 6 – Internal Anatomy of a Cockroach)

Respiratory System

Usually there are 2 pairs of spiracles on the thorax and 8 pairs on the abdomen. The spiracles penetrate the body wall and an opening which directly connects to the insects respiratory system (tracheal tubes). As the tracheal tubes branch interiorly they become smaller tubes known as tracheoles. The tracheal system supplies oxygen to and removes carbon dioxide from all parts of the body. Oxygen is taken directly to the cells by the tracheoles and is not carried in the blood as in man.

Reproductive System

In insects the females always exist, but in some species males are unknown. Most reproduction takes place with the males fertilizing the eggs of the females. Nonsexual reproduction occurs as part of the life cycle of some insects, such as aphids. The sexual organs are located in the abdominal cavity.

Muscular System

The muscles of an insect are transparent or yellowish-white in color. They are the means by which the organs and appendages are put into motion. One can observe the action of the muscles when an ant lifts up an object weighing more than its own weight.

Insect Development

Egg

Life begins from an egg. Temperature, humidity and light are some of the major factors influencing the time of hatching. In general, the eggs are fertilized by the male before they are deposited. The flesh flies and some aphids give birth to living young. In these cases, the eggs are hatched within the female body before the young are passed outside. There are aphids and parasitic wasps in which the females do not have to fertilize their eggs. This method of reproduction is called parthenogenesis.

Eggs come in various sizes and shapes; elongate, round, oval and flat. Eggs of cockroaches and praying mantids are laid in capsules. Eggs may be deposited singly or in mass on or near the host, such as in soil, on plants, animals and building structures.

Instar and Metamorphosis

Metamorphosis is a series of changes which an insect passes through in its growth to reach adulthood. When a young first hatches from an egg, it is in the first instar. After feeding for a time, the first instar young grows to a point where the skin cannot extend any further; therefore, the young must molt (shed its old skin)(Fig. 7), in order to have a new skin to grow. After the first molting, the young is now in the second instar. After another molt, it is in the third instar and so on. The number of instars varies with different insects and, in some cases, varies with the temperature, humidity and availability and kinds of food. Metamorphosis is controlled by chemical hormones. Man-made hormones are being developed for use as insecticides.

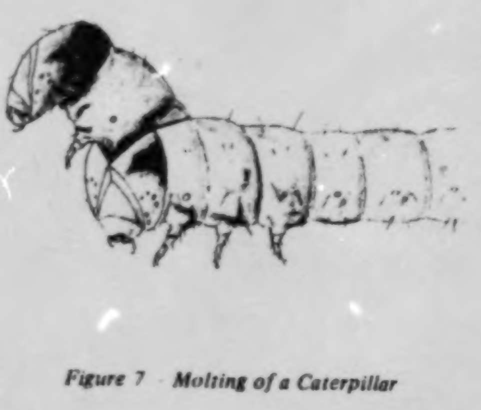


Figure 7 Molting of a Caterpillar

No Metamorphosis

Some insects have no structural change except in size between the time of birth and the completion to the adult stage (Fig. 8). With each successive instar, the insect grows only in size by molting until reaching maturity. Examples are silverfish, firebrats, sucking lice and springtails. The food and habitats of the young are similar to the adult.

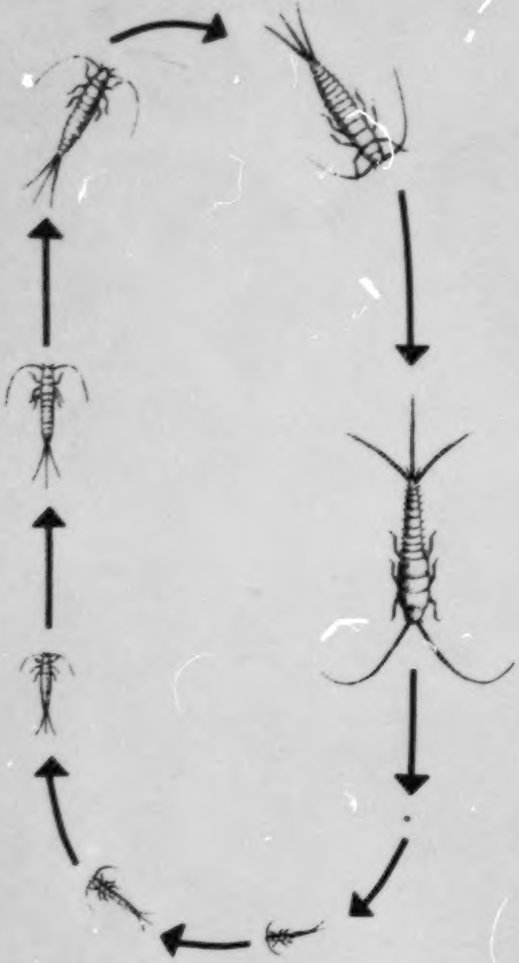


Figure 8 – No Metamorphosis. Life Cycle of a Silverfish

Gradual Metamorphosis

Insects in this group pass through 3 stages of development before reaching maturity: egg, nymph (young) and adult (Fig. 9). The nymph resembles the adult in general form, eats the same food and lives in the same environment. The change of the body is gradual and the wings become fully developed at the adult stage. Examples are cockroaches, crickets, termites, conenose bugs, bed bugs, book lice and earwigs.

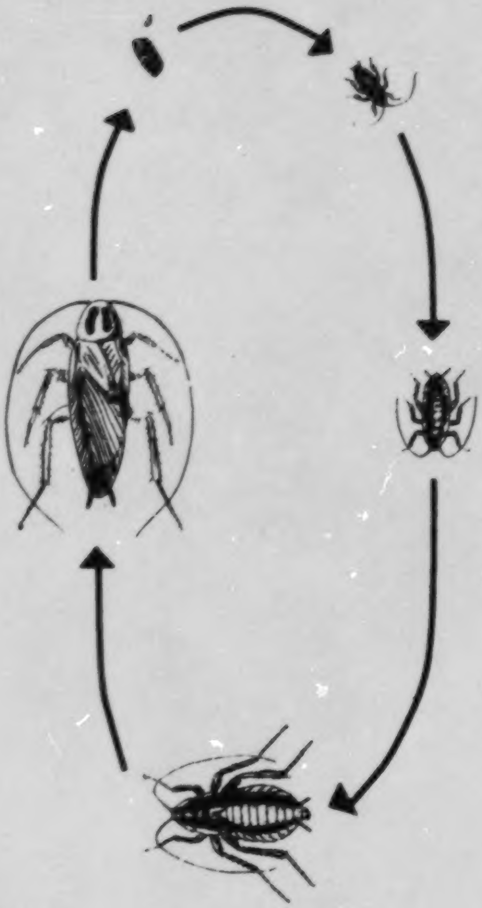


Figure 9 – Gradual Metamorphosis. Life Cycle of a German Cockroach

Incomplete Metamorphosis

The insects with incomplete metamorphosis also pass through 3 stages of development: egg, naiads (young) and adult (Fig. 10). The adult is completely different in appearance from the young. Examples: dragonflies, damselflies, mayflies and stoneflies. In this section the pest control operator will not be concerned with insects in this group.

Complete Metamorphosis

The insects with complete metamorphosis pass through 4 stages of development: egg, larva (young), pupa and adult (Fig. 11). The young are entirely different from the adults and they usually live in different situations and in many cases feed on different foods than the adults. Examples: beetles, moths, butterflies, flies, mosquitoes, fleas, bees, wasps and ants.

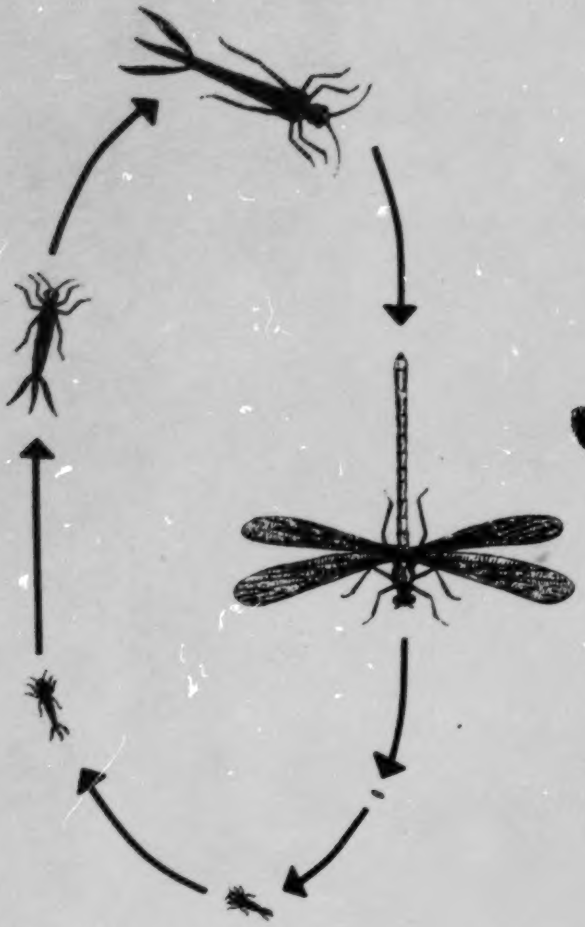


Figure 10 – Incomplete Metamorphosis. Life Cycle of a Damselfly

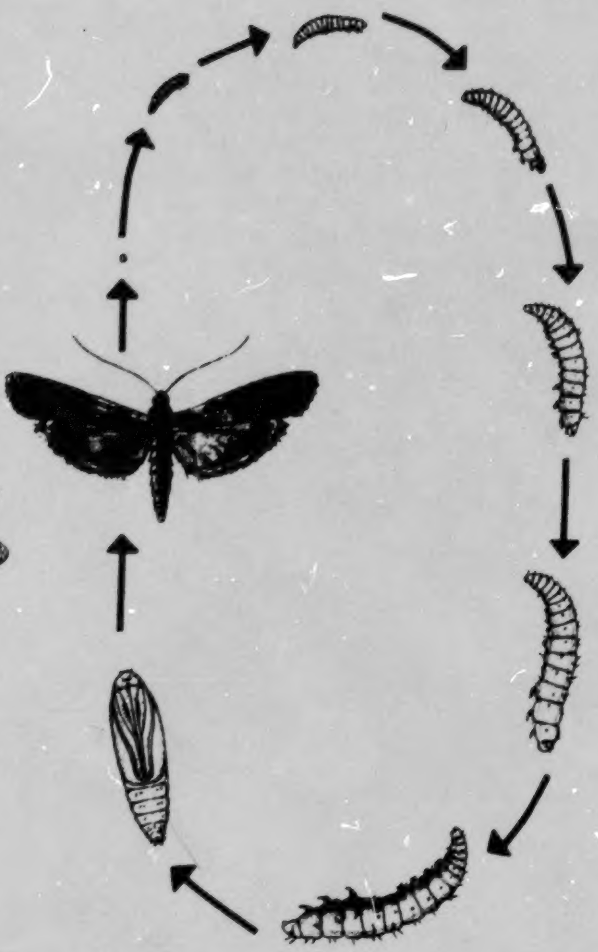


Figure 11 – Complete Metamorphosis. Life Cycle of Indian-Meal Moth

Larva

Larva is a form after hatching from the egg. The moth and butterfly larvae are called caterpillars; some beetle larvae are called grubs and some fly larvae are called maggots (Fig. 12). The larvae of moths and butterflies may have legs or legs may be completely absent like many of the maggots that the pest control operator will encounter. The stored food weevils are legless, while many other kinds of beetles have 3 pairs of legs.

Pupa is sometimes called the resting stage, but is one of the active periods in which the adult legs, wings, antennae, reproductive organs and other parts begin to develop.

After the pupa develops, the adult that emerges is completely different from the young. Many of the adults are injurious to plants and animals during this stage, but not as injurious as the young.

Classification

Living organisms can be classified or grouped into 2 kingdoms: animal and plant. Insects, centipedes, spiders and scorpions are in the animal kingdom. From this major grouping, one progresses downward to smaller categories: phylum, class, order, family, genus and species. Examples of the classification of several common animals is presented in Table 1. Insects and their relatives then are grouped into a smaller category, Arthropoda, which is a phylum. The following key will guide you to some classes of pests in the phylum Arthropoda. This is followed by another key which will guide you to some orders of insects encountered by pest control operators.

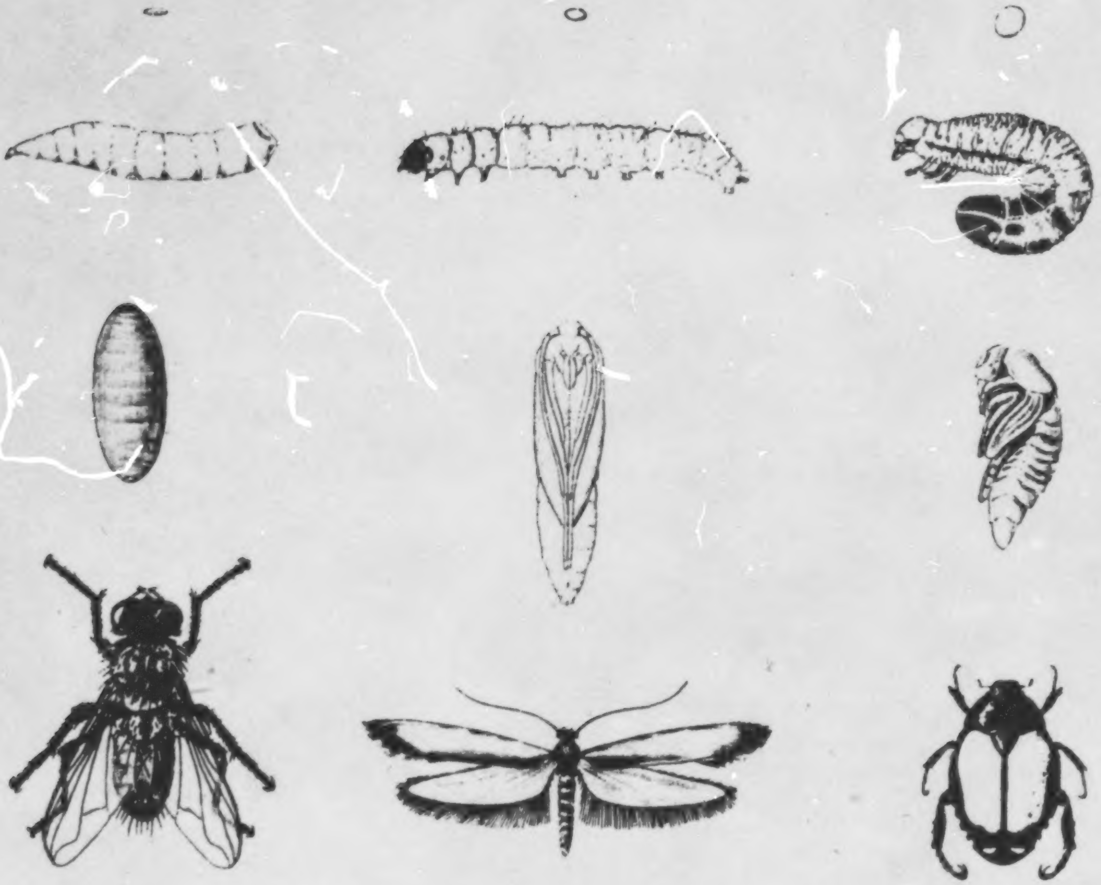
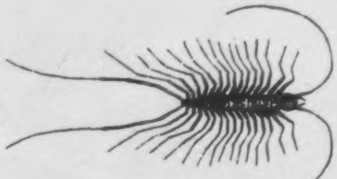


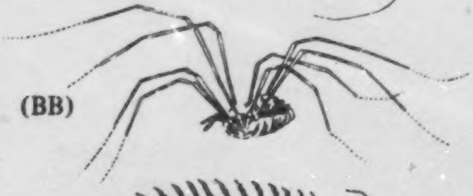
Figure 12 – Four Stages of Development of Housefly, Webbing Clothes Moth and Japanese Beetle

KEY TO SOME CLASSES OF MATURE PESTS IN THE PHYLUM ARTHROPODA

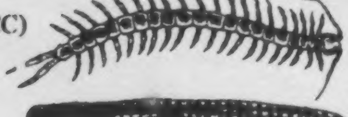
1. With more than 10 pairs of legs and elongated like earthworm (AA). . . . . 2 (AA)



With less than 10 pairs of legs and usually not elongated (BB) . . . . 3 (BB)

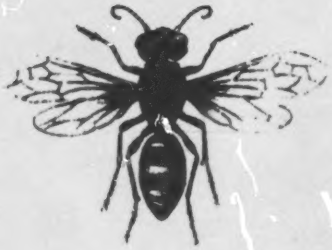


2. Most body segments with 1 pair of legs each (CC) . . . . CHILOPODA (centipedes) (CC)

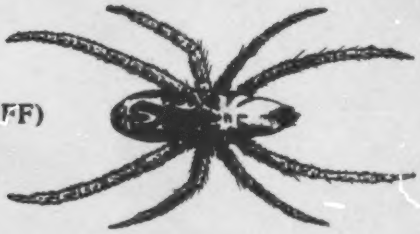


Most body segments with 2 pairs of legs each (DD) . . . . DIPLOPODA (millipedes) (DD)

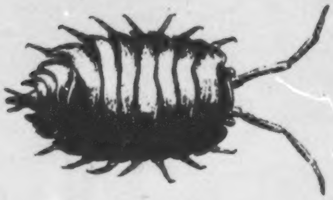
3. With 3 pairs of thoracic legs; 3 major body parts; 1 pair of antennae; often with 1 or 2 pairs of wings (EE) . . . . INSECTA (EE)
(insects)



With 4 or more pairs of legs; 1 or 2 body parts; wings absent (FF) . . . . 4 (FF)

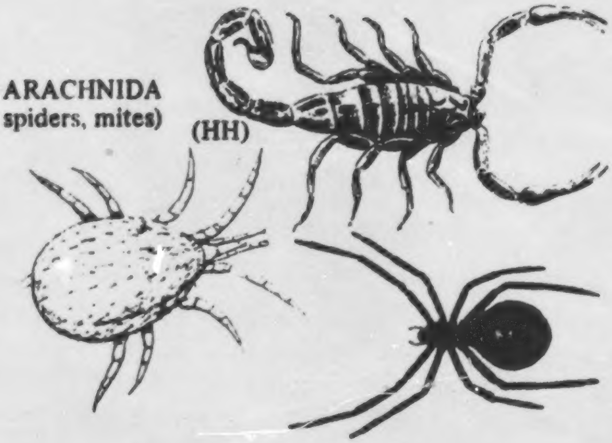


4. Five or more pairs of legs; 2 pairs of antennae, but one pair may be difficult to see (GG) . . . . . . CRUSTACEA (GG)
(sowbugs and pillbugs)



Four pairs of legs; antennae absent (HH) . . . . ARACHNIDA
(ticks, scorpions, spiders, mites)

(HH)

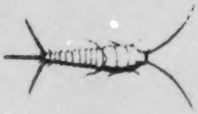


KEY TO SOME ORDERS OF MATURE PESTS IN THE CLASS INSECTA

1. Wings absent 2

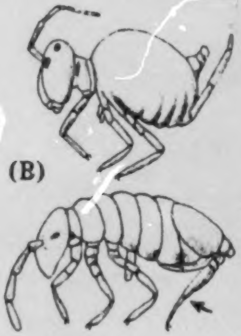
1'. Wings present (the hard covering over the abdomen of a beetle is the forewings) 11

2. Three long thread-like filaments at end of the abdomen (A) . . . . **THYSANURA** (silverfish, firebrats)


(A)

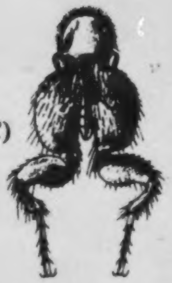
2'. Three long thread-like filaments absent at end of the abdomen 3

3. Abdomen with less than 6 segments; spring-like appendage usually present at the posterior (B) . . **COLLEMBOLA** (springtails)

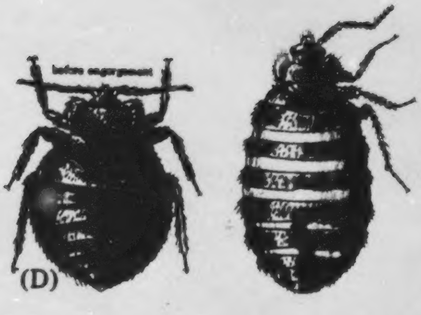

(B)

3'. Abdomen with more than 6 segments; spring-like appendage absent at posterior end of the abdomen 4

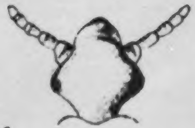
4. Body extremely flattened from side to side (C). . . . . **SIPHONAPTERA** (fleas)


(C)

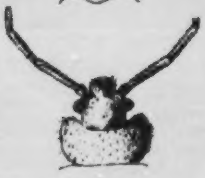
4'. Body not extremely flattened from side to side (D) 5


(D)

5. Antennae not longer than the length of the head (E) . . . . **ANOPLURA** (sucking lice)

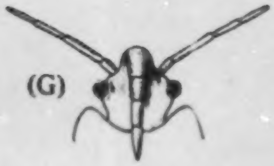

(E)

5'. Antennae distinctly longer than the length of the head (F). 6

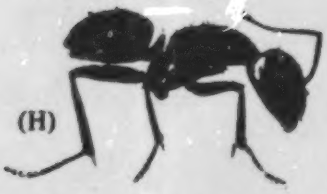

(F)

6. Jointed beak protruding from underside of the head (G) . . . . **HEMIPTERA**
(bed bugs, conenose bugs)

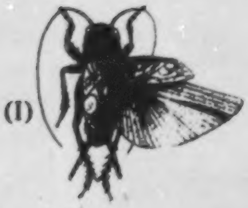
6'. No jointed beak protruding from underside of the head 7


(G)

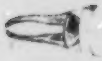
7. Abdomen strongly constricted at the base (H) . . . . **HYMENOPTERA**
(ants, velvet ants)


(H)

7'. Abdomen not strongly constricted at base (I) 8

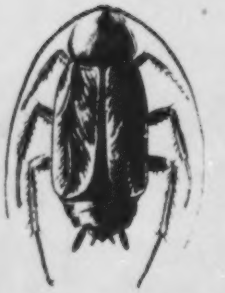

(I)

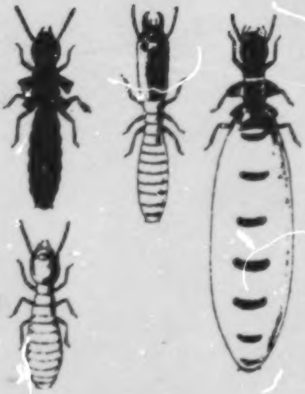
8. Forcep-like appendages present at end of the abdomen (J) . . . . . . **DERMAPTERA**
(earwigs)


(J)

8'. Forcep-like appendages not present at end of the abdomen 9

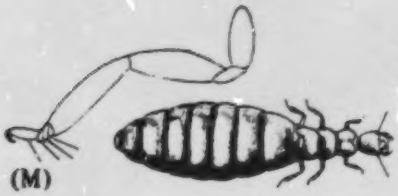
9. Head viewed from above not wider than the broadest part of the thorax (K). . . . . **ORTHOPTERA**
(cockroaches, crickets)


(K)



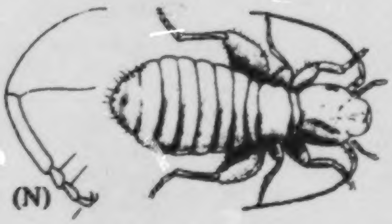
(L)

9'. Head viewed from above wider than the broadest part of the thorax (L) 10



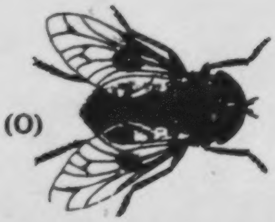
(M)

10. Tarsi with 4 segments; cerci present but may be inconspicuous (M). . . . . ISOPTERA (termites)



(N)

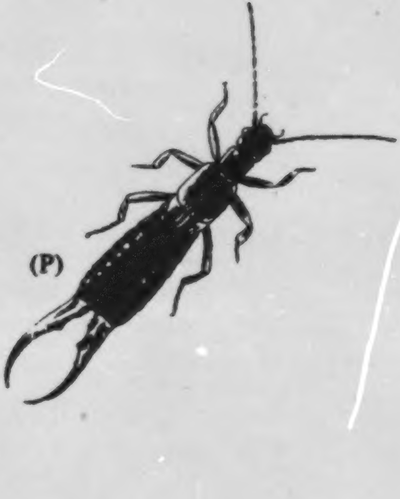
10'. Tarsi with 3 or fewer segments; cerci absent (N) . . . . PSOCOPTERA



(O)

11. One pair of wings present (O) . . . . DIPTERA (flies, mosquitoes)

11'. Two pairs of wings present 12



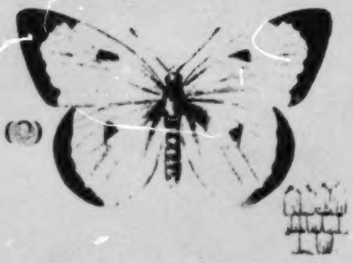
(P)

12. Forcep-like appendages present at end of abdomen (P) . . . . DERMAPTERA (earwigs)

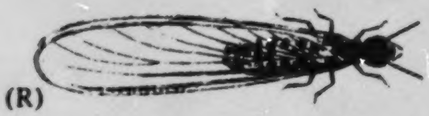
12'. Forcep-like appendages not present at end of abdomen 13

13. Parts or all of the wings covered with scale (Q) . . . . LEPIDOPTERA (butterflies, moths)

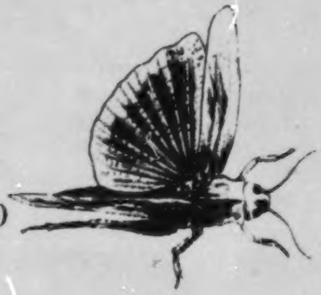
13'. Wings not covered with scales 14


(Q)

14. The whole front wings like a window in that it can be seen through (R) 15

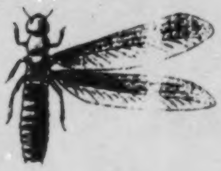

(R)

14'. The whole front wings cannot be seen through. (In Hemiptera posterior half may be seen through) (S) 17

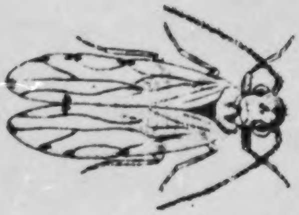

(S)

15. Front and hindwings very nearly equal in length and shape (T). . . . . . ISOPTERA (termites)

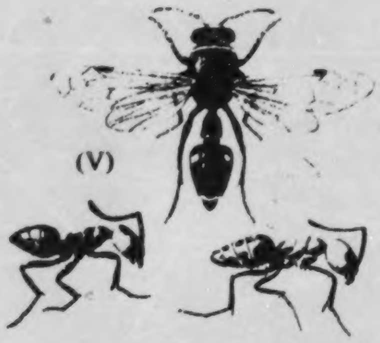
15'. Front wing longer and larger than hind wing 16

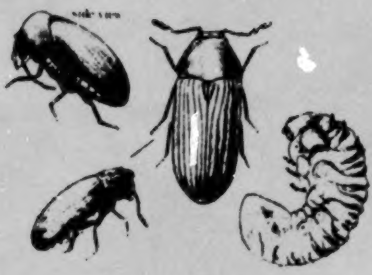

(T)

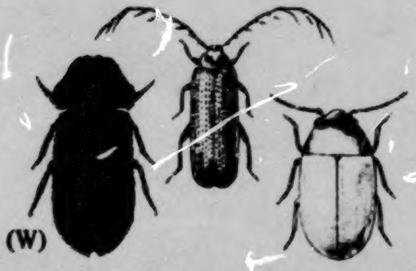
16. Tarsi 2 or 3 segmented; abdomen not constricted at base (U) . . PSOCOPTERA (psocids)


(U)

16'. Tarsi 5 segmented; abdomen strongly constricted at base (V). . HYMENOPTERA (bees, wasps, ants, velvet ants)

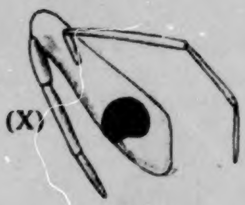

(V)





17. Front wings shell-like and without veins (W) . . . . COLEOPTERA (beetles)

17'. Front wings with veins 18



18. Jointed beak protruding from underside of head (X). . . . . HEMIPTERA (conenose bugs, grass bugs)

18'. Jointed beak not present . . . . ORTHOPTERA (cockroaches, crickets)

Table 1 Examples of Animal Classification

	Man	Sowbug	Black Widow Spider	German Cockroach
KINGDOM	Animal	Animal	Animal	Animal
PHYLUM	Vertebrata	Arthropoda	Arthropoda	Arthorpoda
CLASS	Mammalia	Crustacea	Arachnida	Insecta
ORDER	Primate	Isopoda	Araneida	Orthoptera
FAMILY	Hominidae	Oniscidae	Theridiidae	Blattellidae
GENUS	Homo	Porcellio	Latrodectus	Blattella
SPECIES	sapiens	laevis	hesperus	germanica

A summary of the diagnostic characteristics of the insect orders commonly encountered by the pest control operator as presented in the following section.

No Metamorphosis

Thysanura: Silverfish, firebrats and bristeltails. They are flattened, wingless and about ½ inch long. Antennae are very long. Two or 3 filament-like appendages present at end of the abdomen. Mouth parts are for chewing. They are very active diurnally and nocturnally. Found in homes and feed upon starchy materials.

Collembola: Springtails. This order is wingless and with short antennae. Spring-like projection usually present on the underside at the end of the abdomen. Mouth parts are for chewing, but are withdrawn into the head. These insects occur in damp places. In homes they are found in bathrooms, kitchens and other areas where moisture is present. They are usually harmless.

Anoplura: Sucking lice. Wingless, flat-bodied insects with head narrower than the thorax. Parasitic on mammals by piercing the skin and sucking blood.

Gradual Metamorphosis

Orthoptera: Crickets, cockroaches, grasshoppers, walkingsticks, praying mantids and katydids. Usually with 2 pairs of wings, the front pair is thickened and leathery and the hind pair is membranous. Mouth parts are for chewing.

Dermaptera: Earwigs. Wings may be present or absent. Forcep-like appendages at end of the abdomen. Mouth parts for chewing. Majority of earwigs are plant feeders and few are predaceous on other insects.

Isoptera: Termites. These are social insects. The workers and soldiers are wingless and dull-white. The male and female swarmers are winged and dark-bodied. Wings are dropped before mating. Mouth parts are for chewing.

Psocoptera: Booklice, psocids and barklice. Members of this group are either wingless or have 2 pairs of wings. Mouth parts are for chewing. A few species infest buildings and feed upon cereal products and the glue and paste in book bindings.

Hemiptera: Conenose bugs, bed bugs, grass bugs, stink bugs. The forewings of the bed bugs are short, scale-like pads and the hindwings are absent; while most bugs in this group have 2 pairs of wings, the front pair being thickened and leathery at the base and membranous at the tips. Mouth parts are for piercing and sucking.

Complete Metamorphosis

Coleoptera: Beetles. Hard, shell-like front wings covering the hindwings. Mouth parts are for chewing.

Lepidoptera: Butterflies and moths. Wings covered with scales. Tongue-like tube used for sucking.

Diptera: Flies, mosquitoes, gnats, punkies, midges. This group has 1 pair of wings. Mouth parts are for piercing-sucking or for sponging or lapping.

Siphonaptera: Fleas. These insects are parasitic on mammals. The body is flattened from side to side. Mouth parts are for piercing-sucking.

Hymenoptera: Ants, bees, wasps. Most members of this order have 2 pairs of wings and have abdomen pinched at base. Mouth parts are for chewing and lapping.

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Swan, L. A. and C. S. Papp. 1972. The Common Insects of North America. Harper and Row. N.Y.

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LEARNING AT HOME

Review Questions – Section 1

1. What type of mouth parts do cockroaches have ________.
2. How many types of mouth parts do insects generally have ________.
3. Name the types of mouth parts ________.
4. Name the types of eyes insects have ______.
5. An insects body has ________ divisions.
6. Name the parts of the Thorax ________.
7. When an insect has 2 pairs of wings, which part of the Thorax are they attached to ________.
8. The abdomen of an insect is generally composed of ________ segments.
9. Name the basic parts of the digestive tube ________.
10. An insect breathes through ________.
11. What is the equivalent of the gizzard in insects called ________.
12. Nerve centers are called ________.
13. The color of an insects muscles is ______.
14. How many pair of spiracles are usually found on the Thorax ________.
15. Name 3 insects that develop with no metamorphosis ________.

OUTSIDE ASSIGNMENTS

1. Try and collect at least 15 species of insects and determine as to order, using the keys in this section.
2. Obtain a 10X hand lens and using the keys, observe the characteristics possessed by different insects as outlined in the keys.
3. Make a neat list of the common pests found in and around the home and note the key points of recognition.
4. Start a note book with this section. During the period of this program and continuing after end of program you should keep adding information from other reference sources.

HOUSEHOLD PESTS

Richard S. Kaae
Associate Professor
California State Polytechnic University at Pomona

ANTS

Ants are one of the most common insects. They belong to the order Hymenoptera (bees and wasps) and can be readily distinguished from other hymenopterous pests by the presence of 1 or 2 nodes or bumps on the narrow waist (petiole) joining the thorax to the abdomen and by their characteristic elbowed antennae (Fig. 13). At first glance, ants superficially resemble termites; however, in termites the petiole is lacking and the thorax is broadly joined to the abdomen. Also, termite antennae are straight and bead-like, and there are distinct differences in the wing structure of winged termites and ants (Fig. 13). The front and hind wings of termites are almost equal in size and shape, with the tip of the wings extending well beyond the tip of the abdomen. In ants, the hind wings are smaller and of different form than the forewing and neither extend beyond the tip of the abdomen.

As with bees, wasps and termites, ants are social in habit. They live within colonies, tend their young and have a distinct division of labor. The size of a mature ant colony may vary from less than 50 to over several hundred thousand individuals depending on species. Smaller colonies are usually situated under stones, in stumps and logs, or in galleries in the soil. Many of the large colonies build large mounds of earth, sticks and debris and are interspersed with a complex system of galleries and chambers.

There are usually 3 forms of castes of ants found within a colony. These castes are the workers, queens and males. The worker is a female whose reproductive organs have not developed. This caste usually lacks wings and is smaller than both the males and queens. In some species there are different size workers in the colony; in others, all the workers are of approximately the same size. The worker caste performs all the labor duties within the colony including building, repairing and enlarging the nest, foraging for food and feeding the young and other adult forms within the nest.

The male ant is usually winged and maintains its wings until death. The male form is typically smaller than the queen but larger than the worker. The number of males within a colony will vary depending on the species concerned and the time of year. The sole function of the male is to fertilize the queen. Correspondingly, most males will be found in the nest immediately prior to the peak mating period and are usually only found in mature or large colonies. Depending on the species, mating occurs either in the nest, on the ground or in the air. When large numbers of males and queens leave the nest for mating, it is referred to as swarming. Adult males do not remain in the nest for a long period of time. Immediately after mating, they die. If males remain unmated, they apparently succumb to predators or elements of the environment.

The female or queen is generally the largest of the 3 castes. She normally possesses wings but loses them immediately after mating. Queens have well developed eyes, an enlarged thorax and a greatly distended abdomen for housing large numbers of eggs. In many species, the primary function of the queen is to lay eggs, but she usually cares for and feeds the first batch of brood when a new nest is first formed. In species where there are more than one queen, as many as several hundred, the queens may perform some of the duties of the workers. The queen typically only mates once but may live and lay fertilized eggs for 15 or more years. Old queens are usually replaced by daughter queens; hence, a colony may survive indefinitely provided environmental conditions remain favorable.

Ants develop with complete metamorphosis. The egg is almost microscopic in size and varies in color and shape, depending on species. The larva is white, soft bodied, legless and lacks a prominent head. The pupae resemble the adults, but is soft, white, immobile and does not feed. It may require from 6 weeks to 2 months or more to develop from egg to adult. As environmental conditions change within one area of the

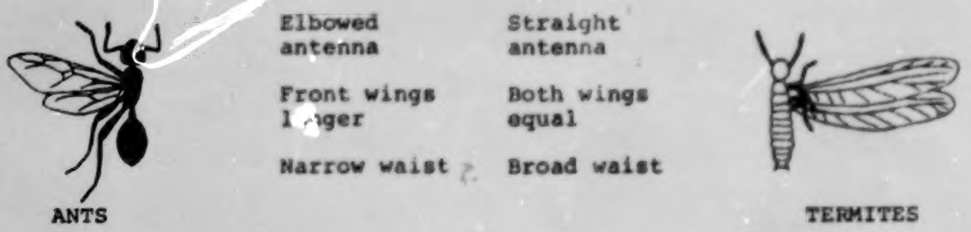


Figure 13 Basic Differences Between Ants and Termites

nest, the workers typically move the brood throughout the colony selecting favorable environmental conditions for development.

A new colony is usually established by a newly fertilized queen. Once finding a suitable location, she loses her wings and digs a nest or seeks a cavity under a stone, in the soil or in wood. She then seals the cavity and rears her first brood by herself on salivary secretions. The adults formed from the first brood are usually undernourished and small, but soon open the cavity and forage outside for food for themselves, the ensuing brood and the queen. As the colony increases in size and number of individuals, new queens and males may be formed.

Although some ants have specific food requirements, most are omniverous and will feed on a variety of foods including sweets, greasy materials, starchy materials, dead and living insects, seeds and a large variety of other plant and animal matter. Many species will prefer to feed on one type of food material if given a choice but will go to other materials if the preferred food is not available. Beside feeding on matter found in the home, many species of ants obtain much of their nourishment either from sweet exudants of plants or insects. The primary diet of many species of ants is honeydew. Honeydew is a sugar based material secreted by many soft body insects including aphids, soft scales, mealybugs, whiteflies and others. These insects feed mainly on the sap of plants. Only part of this sap is completely digested. The rest is secreted in the form of honeydew. Ants are commonly found in close association with these insects and readily lap up the honeydew as it is excreted. Many species of ants will actively tend aphids and other honeydew excreting insects. It is not uncommon to observe an ant approach an aphid from the rear and first stroke the aphid's abdomen with one antenna and then the other. Immediately following this a drop of honeydew will exude from the anus and is readily consumed by the ant.

Ants mainly locate their food by foraging at random. Their strong sense of smell probably is essential once food is in the immediate vicinity. Their eyesight is thought to be extremely poor and of little use in locating food. They forage by day, night or both, depending on the species. Once a scout locates a source of food, she carries a piece back to the nest and alerts other workers. Many species lay down a pheromone chemical along the path from the food source to the nest, thus giving alerted workers a clear odor trail to follow to the food. Most species of ants also actively seek water and if necessary, will travel a considerable distance in search of it.

Identification

There are several hundred species of ants found in the United States. Over 20 species enter structures and are of some economic concern. Because of limited space we will limit our discussion to the 8 most common ant pests. The common house infesting species are illustrated in Table 2. Ants may be divided for identification into 2 groups; those with 1 petiole segment, hence 1 node or bump and those with 2 petiole segments, the double node ants. In the illustrations of Table 2, this separation is used. A hand lens is needed for examining the smaller ants.

Biology

Argentine Ant

The Argentine ant is well established in the southern half of the United States and occurs sporadically throughout other states. Because of the aggressive and competitive nature of this species, it tends to drive other species of ants out of areas where it has become established. Therefore, over most of its distribution, the Argentine ant is by far the most commonly encountered species.

The nest of Argentine ants may be situated wherever light is excluded, including both indoor and outdoor localities. Typical nesting sites include exposed or covered soil, rotting wood, plant cavities, potted plants inside buildings, under buildings and sidewalks, and many other locations. The adaptability of this insect is the prime factor for its success. During the spring and summer months, the number of nests and ants gradually spread out and increase over large areas, particularly along edges of sidewalks, under shrubbery and other situations with adequate moisture. However, as winter approaches, large numbers of nests and ants decrease, with many nests congregating into one large nest that is usually located in a well defined locaility. If located outdoors, winter nests are usually deep in the soil (up to 6 inches). Argentine ant nests frequently move indoors during the winter months, especially if outdoor conditions become too cold, wet or dry.

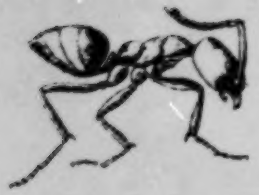
The Argentine ants prefer sweets, but will readily feed upon meats, dead and live insects, seeds and occasionally starches. In areas where this species is found, it is undoubtedly the most common species of ant invading the home. They forage both day and night and travel in well defined trails.

Odorous House Ant

The Odorous house ant is distributed throughout the United States from sea level to below

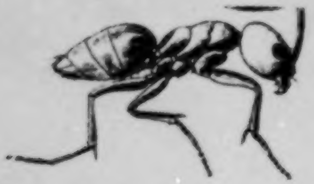
Table 2. Identification of Common Ant Species

Single Node Ants



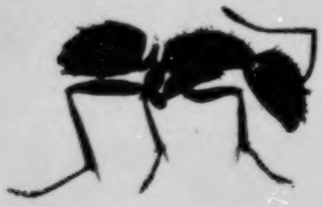
Argentine ant
Iridio myrmex humilis

Workers 1/16 to 1/8 inch and light brown to brown in color. Base of abdomen rounded. Single node erect. Forage in trails.



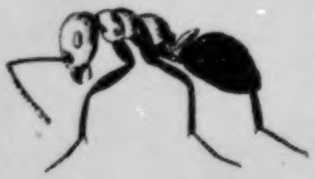
Odorous house ant
Tapinoma sessile

Workers 1/8 inch and brown to black in color. Node nearly hidden by gaster. Forage in trails.



Carpenter ants
Camponotus sp.

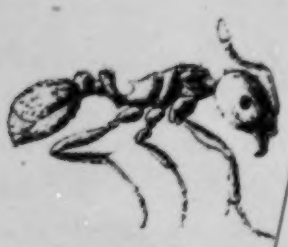
Workers 1/4 to 1/2 inch and black or black and red in color. Profile of thorax evenly rounded. Our largest ants.



Field ant
Formica (several species)

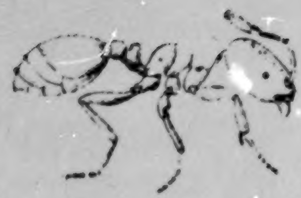
Workers 1/8 to 3/8 inch and reddish to dark brown in color. Thorax swaybacked. Single erect node. Forage in trails.

Double Node Ants



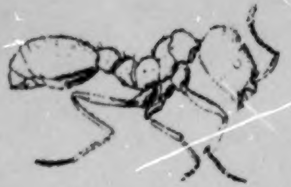
Pavement ant
Tetramorium caespitum

Adults 1/8 inch and light brown to blackish in color. One pair small spines on thorax. Head and thorax with many fine but distinct parallel lines.



Thief ant
Solenopsis molesta

Adults 1/16 inch and reddish, yellowish or pale brown in color. A shiny and slow moving ant. Only attracted to fats. Our smallest ant.



Fire ants
Solenopsis (several species)

Workers 1/16 to 1/4 inch and yellowish to reddish to blackish in color. Antennae with club made of 2 segments. Readily sting.

10,000 feet elevation and ranks only second to the Argentine ant as a household pest. This ant is very similar to the Argentine ant in nesting behavior and tends to be displaced by the latter species when nesting areas overlap. Favored sites include soil beneath stones, boards, sidewalks and in walls or beneath floors of houses. This species prefers sweets but will feed on almost any household food. It readily tends aphids and other honeydew secreting pests.

Colonies are typically large, have many queens, and tend to move indoors during the winter months in response to a lack of suitable food (e.g., decline in aphid population) or in response to unfavorable environmental conditions. The odorous house ant travels in well defined trails. They derive their name from the fact that when crushed, their bodies produce a strong odor of rancid butter.

Carpenter Ants

Carpenter ants are widely distributed and are among the largest of ants occuring in the United States. The workers may be as large as 5/16 inch in length and the reproductive forms grow to 3/4 inch. These ants also characteristically have smaller workers (about 1/4 inch) in the same colony. Two of the more important species found in the United States are Componotus pennsylvanicus (black carpener ant), a predominantly eastern species, and Camponotus vincinus, a predominantly western species.

Carpenter ants commonly nest out-of-doors in fallen trees, rotten logs, tree stumps and wooden structures. However, they will travel several hundred feet in search of food or water. They typically forage at night and will readily enter the home in search of food. These ants feed upon dead and living insects, honeydew, plant sap and almost any household food. Carpenter ants do not produce odor trails, but frequently follow the trails of other ant species.

Swarming of reproductive forms occurs in the spring or early summer months. It is not uncommon to find large numbers of these winged forms in the home at this time of the year. Although carpenter ants do not sting, they will bite. They frequently torment campers and vacationers by attacking people and getting into food.

Harvester Ants

Several species of harvester ants are distributed throughout the United States. These ants do not invade or nest in structures, but form large nests in lawns, around door steps, paths and other areas in and around yards. The preferred nesting site is in open fields and when new housing is built near these nests, these ants are especially common. The workers are very pugnacious when disturbed and will readily bite and sting. These ants have been known to kill small animals. Their nests are large and characteristically have all vegetation clear from 3 to 20 feet around their center. One or more paths may lead from the entrance hole to the surrounding areas, and these pathways may range up to 200 feet. The nest consists of many subterranean tunnels and chambers and average from 10- to 15,000 individuals. These ants are seed eaters. The workers bring seeds into the nest, often with the husk and air float still attached. The seeds are stored in the nest until consumed. Once the seed kernel is consumed, the seed coats, air floats and other debris are carried to the outer edge of the crater and dropped. In this way, the outer rim of the crater becomes covered with vegetable refuse.

Thief Ant

The thief ant is distributed throughout the nation. This is one of our smallest species of ants with workers averaging 1/16 inch in length. This ant acquired its name from the fact that their workers will readily enter the nests of larger ant species and steal food and feed upon immature forms. When invading the home or other structures, preferred foods are fatty materials such as ham, bacon, cheeses, grease and prepared meats. These ants are not normally attracted to sweets, starches or fruit, but if preferred foods are not available, these materials may be invaded. Because of the small size of this ant, it is not easily kept from any container in which food is stored. Also, unobservant people or those with failing eyesight may complain about the flavor of food without realizing that the food is covered with theif ants.

Thief ants nest both inside, outside or under the home. Preferred outdoor nesting locations are rather diverse and include open fields, under piles of rock or large stones, in rotten wood or other similar locations. Inside the home they are apt to be most prevalent around kitchen sinks and in cupboards. They typically nest in cracks and crevices in cupboards or walls or in the masonry of the structure. Nests may be very large, often containing over 100,000 individuals and when mature, many queens.

Pavement Ant

The pavement ant was first introduced from Europe into the North Atlantic States and has subsequently spread to many other areas. In this species individuals forage and they do not travel in trails. Preferred foods are meats and greases, although they will readily feed on sweets, insects, seeds and other materials. In some areas, the pavement ant is an agricultural pest, feeding on the bark and cambium layers of the main stems and roots of many plants.

Outdoors the nests are located in the soil beneath stones, along the edges of curbing and in cracks in the pavement, especially pavement located near lawns. In the home this species will occasionally nest in walls, under floors and in insulation. Many problems arise when large nests are located below slabs on grade foundation. In these instances, the ants may readily enter the home through cracks in the foundation, and the location of the nest makes control difficult. Nests are frequently located near some source of heat within the home.

The pavement ant is aggressive and will drive other ants out of the general area of its nest. Although these ants can sting and bite, they are not aggressive toward man, and when they do sting, it is not exceedingly painful.

Fire Ants

Many ants of the genus Solenopsis are referred to as fire ants because of their painful or fiery sting. These ants typically do not nest in structures. Nests are usually located in hard or soft, dry ground and frequently with the entrance hole next to objects such as rocks, wood blocks, cow chips and other debris. The nests are usually small with small craters around the entrance and are frequently located in a series.

These ants travel in trails and are attracted to sweets and fats, as well as living animals. They may enter the home but most problems arise when these pests are located in the yard. They are very pugnacious and will rush from the nest and bite and sting upon the slightest provocation. This ant is also an important agricultural pest in some areas.

Field Ants

Since there are a number of species of field ants in the United States, the genus is distributed throughout the nation. Although there is some variation in the preferred nesting sites of different species of this ant, none nest in homes. The brown field ant, Formica cinera, is frequently found nesting in cracks in sidewalks, along foundations of buildings, at the base of trees and in open fields. Nests are usually large and have distinct craters. Preferred food materials include sweets, honeydew and dead and living insects.

One species, Formica rufla, the slave ant, will enter the nest of other ants and steal their larvae and pupae. These immature forms are subsequently brought back to their captor's nest and, after emerging as adults, perform many work duties for the slave ant. Field ants only occasionally enter the home in search of food, but may be of concern since large numbers of nests may occur in backyards and recreational areas.

Control

The control method employed may depend on the ant species involved, and more specifically, where the ants are nesting. The 3 basic methods of ant control are, the use of insecticide barriers to prevent ants from entering a structure, the use of baits to poison ants in their nests, and the direct application of toxicants to the nest.

The most reliable means of ant control is to locate and treat the nest directly. This is done most easily when ants are nesting outdoors. To treat individual mounds, spray 4 to 5 foot area surrounding the mound and then flood the entrance of the mound with the toxicant. It will do little good just to flood the entrance, as this will not kill all the ants in the nest, and those remaining will form a new entrance. Broadcast spray of emulsions or wettable powder have been used in areas where mounds are numerous.

Direct nest treatment may also be used with indoor nesting species like the odorous house ant and thief ant if the nest can be located. Nests may frequently be located by following several individual workers, especially those carrying food. Following individual workers can be misleading; ants may disappear behind a baseboard or similar structure, and the nest may be located a considerable distance from their point of disappearance. However, if a nest is located in a wall void or similar area, a toxicant should be blown into the nest through existing openings (e.g., light switches) or through small holes drilled in the void.

If nests cannot be located or if it is not practical to treat them directly, barriers of long lasting residual chemicals can be used. Barriers are most effective if they can be placed around the entire perimeter of the nest. This may be difficult indoors if the wall in question is joined by many other walls or if the nest is beneath flooring.

A barrier can be applied to keep outdoor nesting species from entering the structure. This should be in the form of a wettable powder or emulsion of a long lasting residual chemical applied to the outside wall from the ground to the bottom of the first window. Other possible entrances into the house should also be treated including posts, pillars, pipes, shrubbery and similar structures. In addition, the soil surrounding a building and crawl spaces can be treated with dusts or granules instead of sprays.

Baits are useful when the nest cannot be located or treated and residual sprays cannot be used effectively. The principle behind baits is to place the bait where foraging workers will readily contact it and take it back to their nests to feed to their young. Baits contain an attractant and a toxicant. Since most ants have distinct food preferences, different attractants are used for different species. Some baits have a sugar base and others have an oil base and some both. Most baits used today contain a weak, slow acting toxicant. This allows the worker to ingest the bait without adverse effects before returning to the nest and dispersing it among the colony.

COCKROACHES

The cockroaches can be recognized by their oval flattened body, elongate hair-like antennae and large saddle-shaped plate (pronotum) which dorsally covers the thorax and projects forward over the head. The adults of most cockroach species have wings and are capable of flight. In those forms with wings, the front pair are leathery in texture, pigmented and serve to protect the second pair of large membranous flight wings. In some species the front pair of wings are distinctively shorter in the females than the males.

There are over 2000 species of cockroaches found in the world. Most of these are subtropical in distribution and are not found in the United States. Approximately 75 species occur in North America. Of these, only 4 or 5 commonly enter structures and are of economic concern.

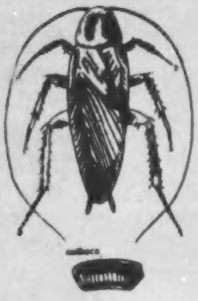
Identification

It is extremely important to be able to recognise the common household infesting species as treatment should vary depending on the species. There are 4 important cockroach species in the United States. They are: the German cockroach, Blatella germanica; the American cockroach, Periplaneta americana; the Oriental cockroach, Blatta orientalis; and the brown-banded cockroach, Supella longipalpa. Other common names like the Croton bug, water bug and black beetle are occasionally applied to a particular species, but they are not generally accepted and if possible should be avoided. Table 3 presents diagnostic characteristics of the stages of each of the 4 house infesting species.

Biology

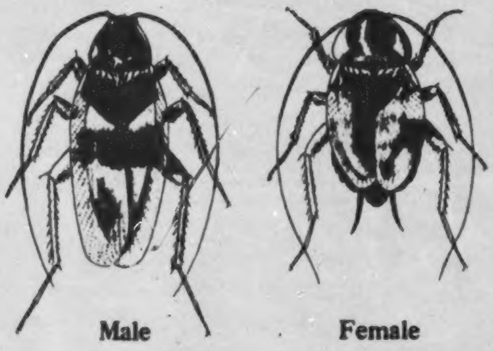
It is not only important to be able to recognize the domestic species of roaches, but a knowledge of their generalized and specific biology is extremely important as treatment will be inherently more successful if based on this information. All roaches develop with gradual metamorphosis. The eggs of the domestic species develop within a leathery case called an ootheca. The number of eggs per ootheca will vary from 8 to 48 depending mainly on the species. The ootheca may be dropped in a suitable habitat or glued to a surface soon after forming, or in some species, it is carried projecting from the tip of the female abdomen until the young are ready to hatch. Once hatched, the nymphs may require anywhere from 70 days to a year or more to reach adulthood depending on the species, prevailing temperatures or other environmental factors. The adult roaches are typically long-lived. A comparison of the biologies of the 4 common cockroach species is presented in Table 4. The reader should not attempt to memorize this chart, but should look for generalities which apply to each species and can be applied to control measures.

Table 3. Diagnostic Characteristics of Common Domestic Cockroaches



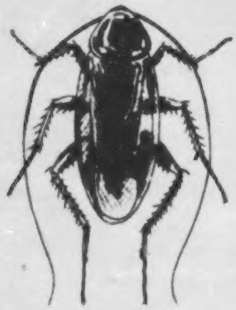
GERMAN

Two dark longitudinal stripes on pronotum; approximately 1/2 inch in length.



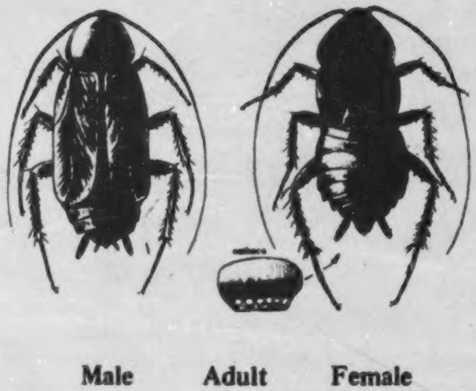
BROWN-BANDED

Two pale bands at base and tip of wings; 1/2 inch in length.



AMERICAN

Brown to reddish brown color; wings cover abdomen; 1 to 1 1/2 inches in length.



ORIENTAL

Almost black in color; wings shorter than abdomen; 1 inch in length.

Table 4. Comparative Biology of Common Cockroaches

	German	American	Oriental	Brown-Banded
Number egg capsules per female*	8	20	8	14
Number eggs per capsule	36	15	16	18
Number generations per year	3	> 1	> 1	1
Time female carries capsule*	30	1	1	1
Length of life cycle	120	500	600	220
Maximum female adult life	250	450	180	200

*Unless otherwise indicated, all data is given as an average and time is given in days.

The common species of cockroaches are omnivorous feeding on a large variety of plant and animal products. Some species show a marked preference of foods but still are capable of developing on a large variety of foods found in pantries, restaurants, bakeries, warehouses and similar locations. Cockroaches are commonly associated with filth and can transmit disease causing germs on their legs, mouth parts and other areas of their body. Common disease microorganisms which may be transmitted by cockroaches include those of diarrhea, dysentary and food poisoning. Besides consuming and contaminating foods, roaches may damage books, wallpaper and other materials containing starches and glue. Roaches will also stain surfaces on which they rest and frequently impart a strong musty odor to these surfaces.

Control

Cockroaches are nocturnal in habit and are not normally seen during the day unless the harborages are disturbed. In heavy infestations, the removal or movement of loose boxes, sacks or similar materials may expose hundreds of roaches. If lights are suddenly turned on during the night or during dark periods in an infested structure, it is not uncommon to see many roaches scurry to darkened areas. Signs of infestations other than living roaches include fecal droppings, full or empty egg cases, cast skins from nymphs, stains and strong musty odors.

Many cockroach infestations undoubtedly begin by the introduction of a few individuals with merchandise, equipment or other materials from an area already infested. Any suspect merchandise should be thoroughly inspected. Although this is frequently difficult, the effort may be worthwhile especially if a structure has a record of recurring infestations.

Proper sanitation is a key to control. Like other animals, roaches require adequate food, water and shelter to survive. Once roaches have been introduced into a structure, infestations are likely to build up much more rapidly, be more severe and more difficult to control if proper sanitary conditions do not prevail. Accumulations of materials such as garbage, rubbish, boxes, sacks, newspapers and empty soda pop and beer bottles should be avoided. Areas of excessive moisture within a structure should be eliminated. Proper cleaning of areas where bits of food or grease may accumulate is also helpful. In general, anything which can be done to reduce the supply of food, water or shelter for roaches will reduce possible infestations.

Once a colony of roaches has established itself in a structure, the advent of proper sanitary conditions generally will not rid the premises of the entire infestation. In this case, chemical control is advisable. Since domestic roaches have different environmental habits and biologies, the method and extent of chemical treatment should vary with species. The German cockroach is considered the most severe pest of the common species. This may be directly related to its life cycle. Note in Table 2 that this species can complete one generation in 1/2 to 1/4 the time of the other pest species. It is no wonder that the German cockroach is found in such great abundance and can infest or reinfest a structure in a comparatively short period of time. Theoretically, the fact that the female German roach carries the egg case until the day before the eggs hatch makes this species easier to control than the other 3 species which drop the case the day after it is formed. Fewer treatments may be necessary with the German cockroach. With this species, if the first chemical treatment is adequately applied and the insecticide is effective, further treatment may not be necessary. Once the female contacts the chemical and dies, the eggs in the case protruding from her abdomen will soon die. With the other domestic species, the egg case may be deposited on a protected surface and not be reached by the chemical. Depending on the species, nymphs may continue to hatch from this case for over a 2 month period. Most chemicals used for cockroach control do not have this long residual action and retreatment is always necessary to ensure adequate control.

The German cockroach prefers areas of warmth and high humidity. In most residences, these conditions and infestations of the German roach are typically confined to the bathroom and kitchen. It may be adequate to treat for the German cockroach in these confined areas. Typical resting places include under the refrigerator in the motor compartment, under sinks where it is moist, under and behind all appliances, as well as in drawers and cupboards when the entire kitchen is heated with a moist heat.

The brown-banded cockroach prefers warm areas but frequents drier locations than the German cockroach. For this reason, while German roaches are almost always found at floor level, brown-banded roaches tend to be found in "up" locations, such as behind mirrors, pictures or in bureaus. This roach may be found in any room and an infestation is frequently spread throughout a structure. This coupled with the fact that the female carries the egg case only a short period make control of this species difficult. It is almost impossible to control the brown-banded cockroach with a single spray application.

The American and the Oriental cockroaches are found as frequently outdoors as they are indoors. This may be due to the lower heat requirements of these species. It is common to find infestations of these roaches in basements. The Oriental cockroach seems to prefer damp, cooler situations and is usually found around the floor level of basements. The American cockroach is likely to be found in upper levels of basements, as between floor joists and braces. Complete elimination of these 2 species may require outdoor as well as indoor treatment.

VENOMOUS ARTHROPODS

SCORPIONS

Scorpions are easily recognized by their more or less crab-like appearance and elongate, fleshy, five-segmented tail appendage terminating in a bulbous sac and prominent sting (Fig. 14). Scorpions have 4 pair of legs with the first pair bearing enlarged pinchers. Although these arthropods bear from 2 to 12 eyes, they have poor vision. Species in the United States range from 1 to 5 inches in length.

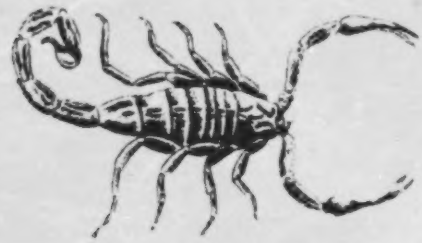


Figure 14 Scorpion

Scorpions commonly occur in the southern states from the Atlantic to the Pacific being most prominent in the southwest. These arthropods are nocturnal, remaining hidden during the day in a variety of locations including under loose stones, loose bark, piles of lumber, leaf litter and a variety of other places especially if moisture is present. During the night they actively prey on insects and other arthropods and are commonly found in the vicinity of lights at night feeding on attracted insects. They occasionally enter the home and may be found on the floor, walls or hidden beneath clothing and other objects.

Scorpions are greatly feared by man; however, they are not aggressive and most stings result when they are accidentally crushed or contacted. Most species are relatively non-toxic to man; their sting is no more dangerous than that of a bee or wasp. A sting may result in a sharp pain and some minor localized swelling which soon subsides. Two species in the United States, Centruroides sculpturatus and Centruroides gertschi, are considered dangerous to man. These species occur in southern Arizona, adjacent areas of California, New Mexico and Texas. The venom of these 2 scorpions is a neurotoxin and may result in restlessness, tissue necrosis and convulsions. An average of 3 people per year die from the sting of these scorpions; most of these are small children. First aid treatment for scorpion stings consists of placing a tourniquet between the sting and body and placing ice on the sting. A doctor should be consulted if dangerous species are know to occur in the area.

Young scorpions are born alive and usually climb on the back of their mother where they remain until after their first molt. Most species usually require 2 to 3 years to reach maturity. Adults are long lived (to 2 years) and can survive for up to 6 months without food.

Control and Safety Procedures

In areas where scorpions are prevalent, the pest control operator can provide a valuable service by advising the customer as to means of avoiding stings. Since scorpions hide in dark areas, it is advisable to avoid leaving shoes, boots and other wearing apparel on the floor overnight. All apparel should be shaken vigorously prior to wearing. Since scorpions cannot climb on slippery surfaces, the legs of a crib can be placed in glass jars. Beds should be moved away from walls. Walking barefoot outdoors in the evening, especially around lights, may be especially risky.

Chemical control is best achieved with residual contact insecticides. Sprays may be applied to the foundation and entries into the house and to certain selected locations inside the home, chiefly around baseboards, moldings, corners and plumbing.

BED BUGS

There are several species of bed bugs that are known to bite man. Most of these are associated with bats or are found in nests of swallows and other birds. If these animals abandon nests that are found in attic or eaves of homes, the bed bugs may leave the area in search of food and enter the living areas of the home. The human bed bug, Cimex lectularis, is primarily a pest of man. This species is about 1/4 inch long, flattened dorsoventrally, reddish brown and wingless (Fig. 15). Females are generally larger than males and the tip of the abdomen is more pointed. Having incomplete metamorphosis, the nymph looks similar to the adult.

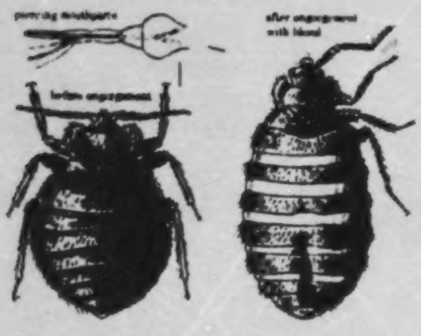


Figure 15 Human Bed Bug

The human bed bug has been a constant companion of man for centuries. It is nocturnal in habit, taking blood meals at night and remaining hidden during the day, It can be found most frequently hiding in the seams and tufts in the beds. Other favored hiding places include behind wooden headboards, loose wallpaper, buttons in the bed, calendars, and in upholstered furniture, backing of pictures, and cracks in the walls and floors.

The human bed bug has glands on its body that secrete an odorous oily material. A room heavily infested with this species will usually have this characteristic odor. Another sign of the presence of bed bugs is blood spots on sheets. These may be due to the accidental crushing of partially fed nymphs or adults, or by the fact that a person bitten may continue to bleed for a short period of time. After feeding this species will defecate; this material will appear as small black spots that are usually found in the vicinity of their hiding places.

The bed bug is chiefly transported from residence to residence as hitchhikers in bedding and old mattresses. Second hand furniture, firewood from demolished buildings or old books are also likely means of introduction.

Persons bitten by bed bugs differ greatly in their reaction. In some there is a marked irritation and localized swelling, but in others, the bite has no apparent effect. This species has been suspected of transmitting diseases of man, but has never been proven to do so.

The human bed bug requires from 4 to 6 weeks to develop from egg to adult during favorable environmental conditions. Adults are relatively long lived and may live up to 18 months. Since this is an indoor species, infestations can normally occur in the home during any time of the year. Under unfavorable conditions, nymphs and adults can live up to 1 year without feeding.

The importance and occurance of the bed bug has been greatly reduced since the advent of the newer synthetic organic insecticides. At one time this pest was one of the most frequently encountered insect by the pest control industry, but today infestation are only infrequently encountered.

Control

Control is usually confined to sleeping quarters in the home. Insecticides must be applied to all the hiding places to achieve good control of bed bugs. Mattresses should be sprayed lightly and allowed to dry for several hours before replacing the sheets and occupying the bed. Extra sheets might be used as a precaution. A pin stream nozzle is used for cracks and crevices and a fan or cone nozzle for mattresses. Each tuft in the mattress and the folds at the edges, as well as the bottom and sides should be treated. Hollow frames, spring coils, headboards, under loose wallpaper and in cracks around nearby doors, windows, and moldings should also receive attention. Treatment of entire rooms by fogging, misting or vaporizing has also been recommended. Outside treatment is seldom necessary, but bird nests and bat harborages should be kept in mind as possible sources of bed bug infestation in unusual cases.

SPIDERS

Although spiders are greatly feared by man, out of the several hundred species that occur in the United States, only a few species are dangerous. Most species are beneficial, feeding on insects and other arthropods. Most spiders are not aggressive toward man, but some will bite if provoked. The bite of many spiders is not harmful nor exceedingly painful; however, the bites of the black widow and the brown recluse spider are sufficiently toxic to be considered dangerous. Little is known about the toxicity of the venom of many spider species.

The black widow spider, Lactrodectus mactans, is present in every state in the union and is found in Canada and South America. Several other species of Lactrodectus occur in the United States and other areas of the world. The males and females of the black widow are distinctly different in appearance. The female is shiny black with a bright red hour-glass shaped marking on the underside of the abdomen. A mature female, with legs fully extended, is up to 2 inches long with the abdomen ranging from 1/4 to 1/2 inch in diameter. The male is much smaller with its overall length less than 1 inch. It is usually lighter than the female in overall color and has light streaks on his abdomen (Fig. 16).

The web of this species is also distinctive. The strands of silk run in many directions so the web appears as a concentration of irregularly arranged threads. The silk strand of the web is considerably heavier and stronger than those of other species that form similarly shaped webs.

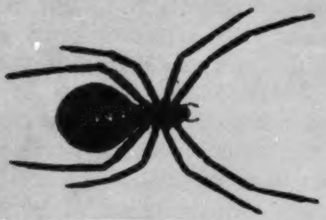


Figure 16 – Vertical View of Female Black Widow

The female hangs upside down in the web. The egg sacs, which contain up to several hundred eggs, are most frequently encountered from May to October. The female typically stays with and guards the sac until the eggs hatch. The young spiderlings remain inside the sac for several days subsequent to hatching. Within a few days after emergence, the spiderlings release strands of silk out into the breeze and are carried off into a new territory. Most of these flights occur during the early fall months. Development from egg to adult may take from 2 to 4 months or more. A female may live a year or more after maturity.

Black widows, as with almost all spiders, feed upon insects and other arthropods. After capturing an insect, they bind it with silk and inject it with a toxin. The insect is subsequently sucked of its nutrients and the empty "shell" is dropped. The web of the black widow is usually located in areas which are frequented by insects, but tend to prefer the shade and avoids full sunlight. In situations where insects are plentiful, the population of black widow spiders may become quite large. The spider is found outdoors in rodent burrows, tall grass and beneath pieces of wood and similar localities, especially if moisture is available. In and around the home, likely habitats include wood piles, behind boxes and other objects in garages, in privies, cellars, furniture, and boxes or wells sheltering water, electric and gas meters. Preferred ecological requisites include availability of water, darkness, infrequent traffic and a source of food.

The black widow spider is not aggressive toward man and when disturbed will generally seek escape and avoid contact. Many bites occur when the female is guarding her sac, this occuring in the spring and summer months. The spider is especially dangerous in outdoor latrines where it may bite hanging genitalia that disturb their web below toilet seats. Black widow bites have also frequently resulted from accidentally squeezing the female when picking up an object or when putting on clothing in which she has been nesting.

The bite most frequently produces a stinging sensation. Pain at the location of the bite may develop in less than 1/2 hour, progressing to the abdomen and legs. The pain may be quite severe for some hours, subsiding after 12 to 48 hours. Some deaths have been reported from black widow spider bites, but in most cases the bites are not fatal. Death is more likely to occur in small children than in adults. All bites from this species should be considered dangerous and treated by a physician.

The brown recluse spider, Loxosceles reclusa, is one of the most common and widespread of several species of the genus Loxosceles that occur in the United States. This spider is presently known to occur in midwestern United States from eastern Texas to western Georgia and north to southern Illinois and Indiana. In the southernmost states, L. reclusa tends to live outdoors under rocks and rubble. Further north it is associated more with houses and outbuildings. In Missouri and Kansas it is found only indoors. This spider frequently occupies boxes, clothing and furniture thus enhancing the chance of transportation and establishment in unoccupied localities. This species recently became established in a small park in southern California but was presumably erradicated through the use of chemicals.

The female of the brown recluse spider is about 1/2 inch long, has 3 pairs of eyes and is yellowish-brown in color with a dark "violin-shape" mark on the cephalothorax (combined head and thorax)(Fig. 17). Another common name of this species is the violin spider. The female lays from 40 to 50 eggs enclosed in a sac. During the summer they hatch in about 3 to 5 weeks and the young reach maturity in 7 to 8 months. Indoors they make webs under tables and chairs, behind baseboards or in corners; however, the spider is an active hunter and does not rely on its web to catch food.

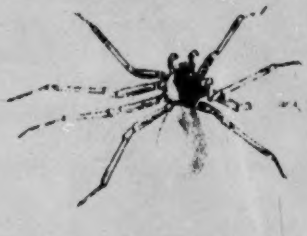


Figure 17 – Brown Recluse Spider

This spider is not aggressive and will retire when disturbed. Most people are bitten when putting on clothes in which the spider has hidden or when rolling on the spider in bed. Unlike the bite of the black widow, that of L. reclusa is localized but it produces considerable local lesions which may ultimately produce an unsightly scar. A bite by this species should be treated by a physician.

Tarantulas are large hairy brown spiders that are frequently encountered in certain areas of the western states, particularly in the southwest. They are especially abundant in the more arid regions, where they live in burrows and under large debris. Large specimens may measure 4 to 6 inches with the legs extended (Fig. 18). About 30 species occur in the United States.

Figure 18 -

In early summer, the females spin a cocoon of silk in which 500 to 1000 eggs are deposited. The eggs hatch in about 3 weeks and the spiderlings remain in the cocoon another 4 to 5 weeks. The female molts in late September and is ready for mating. During the breeding season, large numbers of tarantulas are frequently observed crossing highways or walking over fields. After mating the males live only a short time, most dying with apporach of winter. The female typically overwinters in sealed burrows. During the spring she reopens the burrows and feeds upon grasshoppers, beetles, and other insects. They are active nocturnal hunters. Because of their retiring nature, the females are not frequently encountered. They reach maturity in 10 to 12 years and may live to be over 20 years old. The males live to 12 to 14 years.

Tarantulas are normally very docile spiders. There are very few instances in which they have been known to bite man in the United States. The bite of the species occuring in the U.S. and most of Mexico are harmless to man and generally not exceedingly painful. Some tropical species are dangerous although the venom is local in effect.

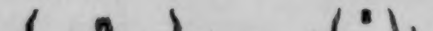
Control

Spiders feed on living organisms and hence are usually found outdoors. However, they are likely to enter and become established in the home where other arthropods abound. Good housekeeping and control of other pests will tend to minimize their presence in the home. Proper screening and other devices to prevent insects from entering the home will also be helpful. Porch lights left on for extensive periods of time in the evening will attract large numbers of insects and hence spiders.

Small numbers of spiders can be killed mechanically with a stick or some other device. Chemical control is best achieved with longer lasting residued chemicals. The extensiveness of application is dictated by the level of the infestation. Power sprays of wettable powders or emulsions are recommended when broad coverage of yards, shrubs and subareas is indicated. Spiders can be prevented from entering the home by trimming shrubbery away from windows and other points of entry. Door thresholds, window sills and other entry points can be carefully sprayed with a residual chemical.

TICKS

Ticks are leathery bodied, eight-legged arthropods that have mouthparts designed to penetrate and hold fast in the skin of vertebrate animals and to withdraw blood. These arthropods can be divided into 2 major groups, the hard ticks and soft ticks. These groups can be distinguished by the presence of a hard shield-like plate on the dorsum covering the front one-third of unfed females and the entire back of unfed males and nymphs of hard ticks. This plate is absent in soft ticks, and the entire integument of male and females is leathery and frequently granular in appearance (Fig. 19). Both the hard and soft ticks are found through the world from the tropics to the artic.



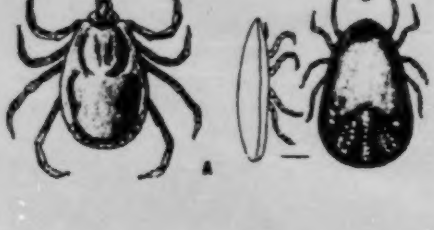


Figure 19 Hard (A) and Soft Ticks (B)

An important behavioral difference between hard and soft ticks is that the latter invariably are associated with the nest or dwelling place of host animal on which they feed. Soft ticks pass through 5 stages; egg, larva, first nymph, second nymph and adult. The eggs are deposited in batches in the nest or living quarters of the host. The six-legged larvae hatch and usually feed for several days prior to molting to the eight-legged nymphal stage. The nymphs and adults do not attach to the host and they take several blood meals before molting. Soft ticks engorge while feeding and may swell to 2 to 3 times their original size. Subsequent to feeding the soft tick leaves the host for a nearby protected area. Both nymphs and adults of soft ticks will readily bite man. In some tick-infested cabins several cases of relapsing fever have been reported over a period of years. These ticks are active in the spring and summer.

The hard ticks pass through only 4 stages; egg, larva, nymph and adult. The eggs are typically deposited in 1 large mass of a thousand or more under stones and trash on the ground. The six-legged larvae require a single blood meal prior to molting into the eight-legged nymph. Two more blood meals are required to complete the life cycle. The nymph and adult feed to engorgement and drop off the host prior to molting and reproduction, respectively. Hard ticks usually attach firmly to the host and may feed from several hours to several days before dropping from the host.

In the United States the Rocky Mountain wood tick (Dermacentor andersoni) is the most troublesome tick. It is very annoying to domestic and wild animals and is commonly found attached securely to the skin of children, hunters and other people who frequent the out-of-doors, especially in brush- and shrub-covered areas. This species occurs in the Rocky Mountain states, Nevada, eastern Oregon and Washington and in California east of the Sierra and Cascade mountains. This tick is capable of transmitting several diseases of man including Rocky Mountain spotted fever, tularemia, and Colorado tick fever. The bite of D. andersoni may also result in a condition called tick paralysis. This condition is not a result of a pathogen but results from a toxin produced by feeding female ticks. If the engorging tick or ticks are removed before the paralysis has proceeded too far, recovery will usually occur rapidly. Advanced cases of this condition may result in death. Adults of this species are most numerous in the spring and early summer months.

The American dog tick, D. varabilis, a species that is commonly encountered throughout the United States except in the Rocky Mountain states, is very similar in habits and appearance to the Rocky Mountain wood tick. It is an important pest of cattle, horses, dogs and will readily bite man. It is usually brought into contact with man by his pets. It is also capable of transmitting Rocky Mountain spotted fever and tularemia.

The brown dog tick, Rhipicephalus sanquineus, is the tick most commonly encountered by the pest control operators. It is associated with domestic dogs, their kennels, runs and houses. In the United States, this species does not bite man, but large populations can build up in the home. Typically a pet dog will pick up a gravid female in a dog kennel, vet's office or another home where a population is already present. This species does not thrive well in outdoor situations. Once the gravid female feeds to engorgement, it will drop off and begin laying eggs within 3 days. They are usually laid in batches between boards, under plaster or carpeting or in cracks and crevices. When the larvae, nymphs or adults are not feeding on the dog, they hide in cracks, crevices, under or around the edge of furniture. If a dog is allowed to sleep in the home at night, the infestation will usually be heaviest in the room where he sleeps. It is not uncommon to find an infestation of several hundred of these ticks in or near the sleeping quarters of a dog.

Under ideal conditions, the life cycle may be completed in about 2 months; however, under normal household conditions, there are 3 to 4 generations per year. Because larvae and nymphs can live to 8 months each without food and the adult a 1 1/2 years, infestation can persist long after dogs leave the premises.

Control

The pest control operator is most frequently called to treat infestations of the brown dog tick. Residual insecticides should be used. The egg stage is generally not susceptible to most insecticides. A residual insecticide will kill the larvae as they crawl over the deposit after hatching and the nymphs and adults as they move from their hiding places in search of a host.

Dusts may be useful for treating sub-floor crawl spaces, under porches and other areas accessible to the dog, but difficult to treat with a spray. When a heavy infestation is present, it is advisable to move furniture and to vacuum up visible ticks. Subsequently, residual sprays and or dusts should be applied to areas frequented by the dog. Particular attention should be paid to baseboards, the dog's sleeping quarters, doorways, window casings and under rugs. If wall to wall carpeting is present, a 1 foot wide barrier of insecticide should be applied on the carpet next to the wall around the entire room. It is not necessary to lift the carpeting as any tick below the carpeting or in the walls will have to cross this barrier to find its host. It may be necessary to treat furniture, especially couches and overstuffed chairs if the dog is allowed on them. Remove cushions and treat all crevices and seams.

In the south during warm weather, it may be necessary to treat outdoor areas frequented by the dog, especially dog houses, crawl spaces and other protected areas. The dog must be treated at the same time as the premise. This should be done by the home owner or the family vet. It is advisable to get a recommendation from the U.S. Public Health Service as to treatment. Liquid washes may give better penetration of the hair that flea and tick powders miss.

FLEAS

Fleas are small, wingless, brown to blackish insects with piercing and sucking mouthparts designed for taking blood. Their bodies are compressed laterally to allow them to move rapidly through hair or feathers, and their legs are designed for jumping. The body, legs and head are equipped with stout spines for gripping the host (Fig. 20).

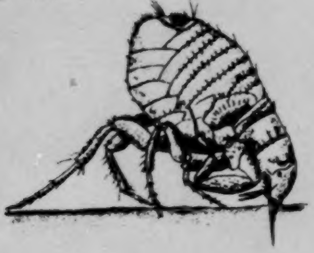


Figure 20 – Front View of a Flea

Ctenocephalides felis and C. canis, the cat and dog fleas, respectively, are capable of feeding on either cats or dogs and both will readily bite man. Both are cosmopolitan in distribution and are frequently found in the home.

The life history of the cat or dog flea is quite similar to that of other fleas commonly encountered in the home. Each species passes through 4 stages; the egg, larva, pupa and adult. The eggs are laid a few at a time although several hundred may be deposited. The eggs are seldom deposited on the hairs of the host but in the nest or sleeping quarters of the host where flea excrement occurs. If deposited on a dog or cat, the eggs fall off when the animal stretches or shakes itself. Depending on temperature and humidity, the eggs hatch in 2 days to several weeks.

Flea larvae are small, 1/8 to 1/2 inch long, somewhat worm-like and whitish in color. They move with a rapid hitching motion, using the mouthparts for grasping and 2 fleshy appendages at the tail end to push. They feed on organic debris including adult flea feces, dried blood, host feces and many other materials. When disturbed they may "flip" in circles to escape. Under ideal conditions, they may complete larval development in about 2 weeks. When mature they spin cocoons covered with grains of sand or debris and change into pupae. It may require as little as a week to complete the pupal period. Adults can live a few weeks to more than a month without food; however, food is required in order to produce eggs.

The dog and cat flea readily bite man but require a dog, cat or other animal to maintain an infestation. They tend to concentrate in bedding or sleeping places of pet dogs or cats, but sometimes an entire yard or neighborhood may be infested, especially if the pet population is high. When pets are available, flea infestations often go unnoticed. If the pet dies, or is taken away during vacations, hungry fleas emerge and become evident.

Sometimes cat or dog flea infestations are encountered where there are no pets. A check often reveals that a stray cat has had kittens under the house or in the basement, or that pets have been removed leaving fleas to develop and seek new hosts. Opossums also carry cat fleas.

The cat or dog fleas are responsible for more home infestations than are any other fleas. If present in large numbers, they will be attracted to a white hankerchief placed on the ground or floor. These species tend to bite as soon as they hop onto a person. Their bites are usually concentrated about the ankles or legs.

As a general rule, infestations of the human flea, Pulex irritans, are harder to find than cat and dog fleas. They do not need other animals, but can survive and reproduce on human blood alone. The larvae live on organic materials found in cracks and crevices in floors. In mild climates, they live in yards. Since the widespread use of vacuum cleaners and good tile, linoleum or hardwood floors, the human flea has become less important. Occasional large infestations are found, especially where standards of sanitation are low. Usually an infestation is small, but often it is persistent.

Human fleas tend to bite about the waist or upper trunk. These fleas are voracious feeders and one flea will bite many times. The fleas feed so rapidly and so much that they eliminate undigested blood (upon which larvae may feed). Blood spots on bed linen and underclothing offer a good clue to their presence if not caused by bed bugs.

The presence of rats on premises is enough indication that rat fleas are present. The oriental rat flea (X. chelopsis) is the species most frequently associated with rats in the United States. The eggs are laid in the rat's nest where hatching and development take place. However, if rats are controlled, fleas leave the nest in search of a blood meal. This exodus from the nest may continue for several weeks as the larvae already present mature and become adults.

The oriental rat flea readily bites man when rats are not available. The tropical rat mite (Ornithonysus bacoti) also develops in nests and will bite man if the rats are removed. For this reason, it is important that mite and flea control measures should be done before and during rat control. The oriental rat flea can pose a serious health problem under certain circumstances. It is the most important vector in the U.S. of Pasteurella pestis, the causative bacteria of plague. Plague is endemic to certain areas of California.

Control

The control of fleas in the home and on the grounds may be broken into a number of steps. Since dogs and cats are the usual carriers of fleas, the animals should be treated with a flea powder or dip. Next, attention should be directed to those localities frequented by the pets, especially areas where animals rest or sleep. The bedding should be discarded or washed with a strong detergent and hung to dry in the sun. Collections of lint and dust should be vacuumed away, since the larvae breed in such material in cracks of the floor boards, under edges of carpet, behind and under furniture and similar places. Basements and areas under houses are havens for dogs, cats and in some areas, opossums. Also, flea larvae often breed in the soil in unexcavated or partially excavated areas in the basement. Wettable powders are applicable in this situation.

Severe infestations of human fleas indoors is usually the result of poor sanitations, since larvae feed upon organic debris. Accumulations of debris and dirt in cracks, crevices and furniture should be vacuumed or otherwise cleaned out to remove harborage and food. The pest control operator should remember that he may be attacked if the fleas are alive while cleaning is taking place, and that flea eggs and larvae can develop inside the vacuum cleaner that is used.

HYMENOPTEROUS PESTS

Honey bees, yellow jackets, paper wasps and other wasps are generally beneficial insects, but they may also be a nuisance and sometimes a serious health hazard because of their sting. In general, they are more common in rural areas as opposed to highly urbanized areas.

HONEY BEE

The honey bee, Apis mellifera, is undoubtedly the most beneficial insect in the world (Fig. 21). Besides producing honey and wax, this is the most important insect in pollinating man's crops. There are many crops that are totally dependent on the honey bee for pollination including most pome and stone fruits (e.g., apples, pears, plums, nectarines), oranges, most seed crops, berries, melons, almonds and many others. Without cross pollination by insects, these crops could not be produced on a commercial basis. The honey bee is constantly increasing in importance as urbanization increases and nesting sites of wild bees are decreasing, and these wild pollinators are being eliminated.

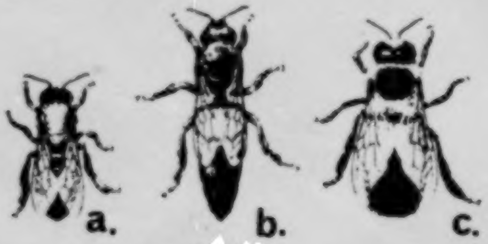


Figure 21 – Three Castes of Honey Bees; Worker (a), Queen (b), [illegible] Drone (c)

Honey bee hives are kept by commercial and amateur beekeepers. For this reason, honey bees are found almost anywhere in the United States, including both agricultural and residential areas. There are also many natural hives that occur throughout the nation. Many residents become very concerned about the presence of these bees having been stung or afraid of being stung.

The reaction of an individual to a bee sting will vary greatly depending on the individual and his past history of bee stings. In the United States, several people per year die from the sting of honey bees. Most who die from bee stings are allergic. Most people who are repeatedly stung over a period of time produce an immunity to the venom; the actual prick remains painful, but the resulting reaction is minimal. A small percentage of individuals do not develop immunity, and a few have a natural immunity. In about 2 percent of the individuals, repeated stinging results in the development of a hypersensitivity to the venom with each sting resulting in a more severe reaction. In many of these individuals, this results in an intensification of the local reaction; in others, the reaction is general and may result in a condition similar to anaphylactic shock. Death may follow within an hour after the sting in very severe cases. As would be expected, many of these deaths occur in individuals who constantly work with bees.

The sting of the honey bee is barbed and usually after the bee attacks, the sting, venom sac and part of the abdomen are torn off and left in the flesh. In this case, the bee usually dies. The sting should be removed by scraping it off with a fingernail or straightedge. Removal of the sting by pulling it out will usually result in squeezing the poison sac and forcing more venom into the flesh.

The honey bee is a social insect. All the duties within the colony are carried out by the worker caste, composed of sexually undeveloped females. A strong colony of honey bees will have as many as 60,000 workers. The colony will also have several hundred drones (males) and usually one sexually mature queen whose duty is to lay eggs. During the spring, in response to heavy nectar flows in the field, more workers are produced and the colony may become overly crowded. In response to this, a new queen will develop and either the new or old queen will leave the colony with a few hundred to over half the worker force in the form of a swarm. The swarm may travel a mile or two before finding an area that is suitable for the development of a new colony. New colonies may be formed in a hollow log, within a wall in a hollow balcony or other cavities around the home. The swarm may settle several times and rest for a day or more prior to finding a permanent home. The activity of the bees in and around the swarm are generally of considerable concern to the home owner. Generally speaking, the bees in a newly emerged swarm are quite docile and will not readily sting; however, within a day or 2, the bees become more aggressive and readily sting.

Control

The honey bee collects pollen and nectar from a large number of plants including ornamentals. When a nectar or pollen source is particularly strong, large numbers of bees may visit a plant or group of plants in a relatively short period of time. If these plants are found around the home, bees may be of concern to the home owner. It is generally not advisable to try to control these bees, as they will not sting if not disturbed, and the large number of blossom visitations will generally cease in a few days.

Swarms found in a tree, bush or on some other exposed areas will not normally remain and generally will move on to a more permanent location within a few days. Unless these swarms are in an area with frequent human traffic, it may be advisable to leave them alone or have someone remove it. The county agricultural commissioner's office, local farm advisors, city police or fire departments usually have a list of beekeepers who are willing to pick up swarms. Many beekeepers will pick up swarms free of charge provided the bees are in the open and of easy access. Some will charge a fee to remove more difficult to reach swarms.

If bees have settled in a wall, balcony, chimney, attic or difficult place to reach, it may be necessary to destroy the hive with an insecticide. The material should be applied as a dust directly to the swarm. This may necessitate drilling holes in walls, or blowing dust into a chimney from above. If the colony has been in the structure for a month or more, it is likely that considerable amount of wax, honey and pollen are present. These materials, plus the dead bees, are likely to attract other scavanger insects and should be removed. This usually necessitates the temporary removal of part of the structure (siding, shingles) to gain access. After removal the area should be treated with a residual dust to discourage insect pests from being attracted to the old location.

YELLOW JACKETS AND HORNETS

There are several common species of yellow jackets and hornets found in the United States; all belong to the genus Vespula (Fig. 22). The biology of these are quite similar. All are social and there may be as many as 10,000 individuals within a colony (depending on species). In the fall the newly emerged queen and males mate. The male and the workers die in the fall with only the young queens overwintering beneath bark or in other protected locations. The following spring the overwintering queen emerges and selects a suitable nesting site, rarely returning to its old nest. She collects materials from rotten or weathered wood, plant fiber and other cellulose

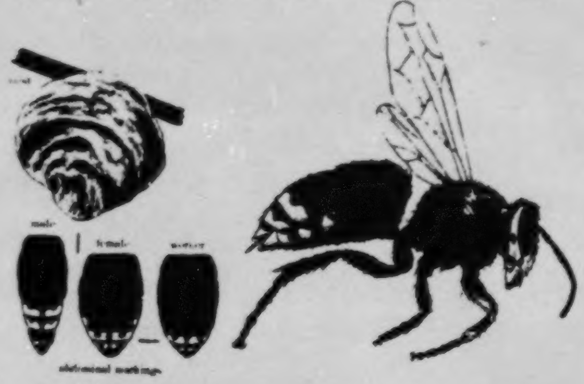


Figure 22 - Adult and Nest of Yellow Jacket

material to mix with saliva and construct a small new nest. She then deposits eggs, one per cell in the new nest. When the eggs hatch, the larvae are fed protein, mainly insects which the queen collects. Upon maturation these larvae pupate and ultimately emerge as adult workers. At this time the sole duty of the queen is to lay eggs. The newly emerged adult worker carries out all the work including enlarging and maintaining the nest and collecting food. The workers feed the larvae protein materials (insects) and in return receive sugar solutions from the larvae.

The workers are all sterile females and can sting. During the latter part of the season late summer, early fall), new queens and males are produced; egg laying is also reduced. As a result, the number of young in the nest is reduced and the workers run short of sweets. At this time the workers actively forage for sweets including nectar, fruit juices, soft drinks and other sources of sugar. They may at this time feed on whole fruits including grapes and pears and cause considerable harassment to the home owner.

Yellow jackets and hornets create problems around campgrounds, recreation areas, backyards, drive-in restaurants and other areas where food and water are found. These wasps are capable of foraging several thousand feet in search of food. The list of food material that yellow jackets and hornets feed upon is quite long. The 2 main categories being meats and liquids high in sugar.

POLISTES WASPS

The Polistes wasps are similar in appearance and habit to the yellow jackets (Fig. 23). These pests at times may be exceedingly numerous, but their nests are never as large as those of yellow jackets. A large nest may consist of 100 to 200 individuals. Unlike those of the yellow jacket, the nest consists of a single more or less circular horizontal comb suspended by a slender stalk (Fig. 24). Like the yellow jackets, the workers actively forage for food in the form of soft bodied insects, fruit juices and honeydew. The activity and role of the queens, males and workers and the life cycle of these wasps is very similar to that of the yellow jackets.

The nests of Polistes wasps are typically located on branches of trees and backyard fences, in burrows in the ground and hollow trees, and under eaves of homes. When disturbed these wasps will readily sting. This situation frequently arises around the home when small children throw rocks at the nests or attempt to jab them with a stick.

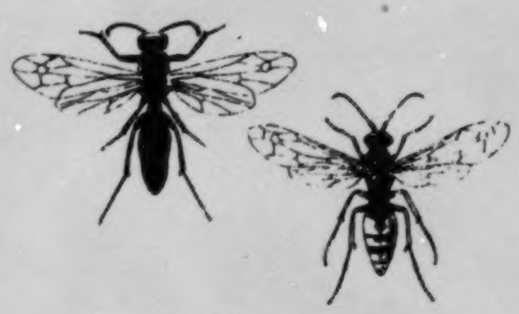


Figure 23 – Adult of Polistes Wasp

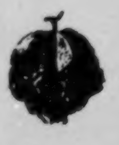


Figure 24 – Nest of Polistes Wasp

CONTROL

These hymenopterous pests can be controlled by introducing almost any insecticide directly into their nests. This can be hazardous to the applicator if certain precautions are not taken. Some applicators prefer to wear protective clothing including heavy full-length coveralls, high top boots, gloves and a bee veil. If these are not available, it is less hazardous to treat the nest at night as these species fly less readily at this time. The probability of being stung is also reduced if the chemical can be applied from a distance using a pencil stream from power spray equipment.

Wasp Freeze is a formulation that appears to show considerable promise in control of hymenopterious pests. This product contains highly volatile solvents and a quick acting insecticide. When this material is applied, the solvent results in a quick reduction of the wasps body temperature and hence in combination with the "quick action" of the toxicant gives an instant knock down. The applicator can clear the area of flying wasps and then direct the pressurized spray into the nest. This ensures instantaneous kill and eliminates or reduces the chance of being stung when attempting to kill the pest during the day.

Indirect control in many cases can be achieved by the use of an attractant bait coupled with a toxicant. If the bait is placed in the problem area, workers pick it up, take it back to their nest and feed it to the young.

FABRIC PESTS

A number of insects will occasionally feed on different fabrics (e.g., termites, silverfish, book lice and cockroaches); however, these incidental pests seldom cause any major damage. Most damage to fabrics result from infestations of carpet beetles and clothing moths. The main fabric pests encountered in the United States are:

Clothes Moths

Webbing clothes moth – Tineola bisselliella
Casemaking clothes moth – Tinea pellionella
Carpet moth – Trichophaga-trapetzella

Carpet Beetles

Black carpet beetle – Attagenus piceus
Common carpet beetle – Anthrenus scrophulariae
Varied carpet beetle – Anthrenus verbasci
Furniture carpet beetle – Anthrenus flavipes

The principle fabrics attacked by these insects are wool and other substances containing a tough fibrous protein called keratin, the main feeding attractant of these pests. Keratin is also the principle protein of hair, fingernails, horns, feathers and hoofs.

Although these insects commonly feed on wool and other fabrics, these materials apparently do not contain adequate vitamins and amino acids (protein) to properly sustain their development. For this reason, fabric pests do not typically feed on "clean wool" but mainly attack wool and other fabrics which have been contaminated with soilage, food spillage, urine or related nutrients. Contamination is frequently difficult to avoid and be caused by perspiration, body oils and even air borne microorganisms.

The clothes moths and carpet beetles develop with complete metamorphosis. However, the larvae are the only damaging stage of these pests. Adults of the clothes moths do not feed and are short lived. Adult carpet beetles commonly feed outdoors on pollen and enter the home to lay eggs in the spring and summer months. The clothes moths are more limited in their diet than the carpet beetles. The larvae of these moths feed mainly on contaminated wool and other materials containing keratin. Carpet beetle larvae will feed on many other materials including dried museum specimens, dead insects, nuts, leather, seeds, cereals and cereal products, and many other dried plant and animal products. Cotton, synthetics and other contaminated fabrics may also be attacked by these pests.

Identification

The clothes moths are small and delicate, rarely over 3/8 to 1/2 inch in length. Unlike most species, these moths are not attracted to lights, but prefer darkness and when disturbed will rapidly conceal themselves in folds or other secluded places. Larval identification is best based on the feeding damage rather than specific morphological characteristics. The carpet beetles can be easily identified in either the larval or adult stage. Adults can generally be separated by body shape, coloration and the presence or absence of a cleft at the rear of the forewings. The larvae are characterized by body shape and the arrangement of hairs and tufts of hairs on the body. Table 5 summarizes the diagnostic characteristics of the adults and larval feeding damage of the Lepidopterous fabric pests. Table 6 summarizes the diagnostic characteristics of the larval and adult stages of the carpet beetles.

Biology

Specific biological and other pertinent facts about the common fabric pests are discussed in the following section.

Webbing Clothes Moth

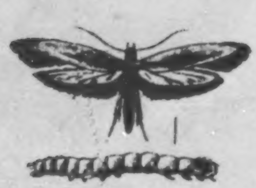
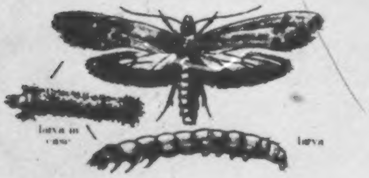
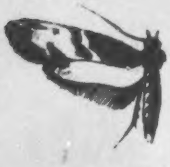
This is the only species of clothes moth that is commonly encountered throughout the United States. It appears to be the most important fabric pest in the Southern states. Like other Lepidoptera, this species passes through 4 developmental stages. The duration of development from egg to adult is dependent on temperature, humidity and greatly upon the availability of suitable food. Under ideal conditions, it will complete 1 generation in 40 to 50 days. Under marginal conditions, this species may require up to 1 or 2 years to complete its development.

A newly emerged first instar larvae will wander until it finds a suitable place to feed (e.g., soiled place on woolen cloth). Unless conditions become unfavorable, it will settle down and feed at this location until approaching pupation. When the young larva finds suitable food, it spins a silken tube from which it feeds. This webbing is frequently covered with fecal pellets and cloth fibers and is characteristic of this species.

Casebearing Clothes Moth

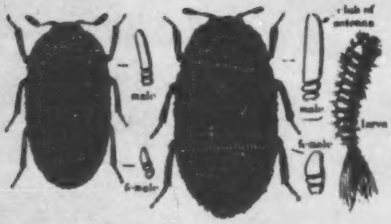
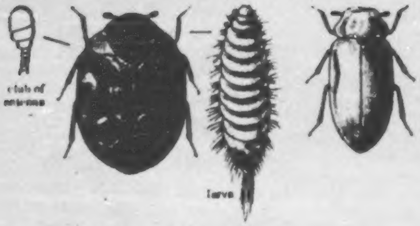
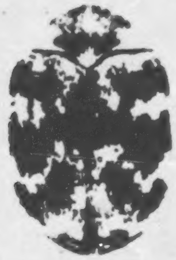
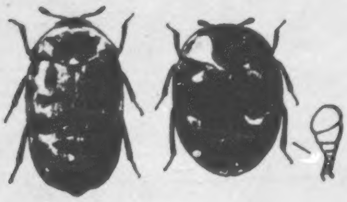
The casebearing clothes moth is distributed throughout nearly all of the populated areas of the world. This species is relatively rare in northern areas of the United States. The life cycle of this species is very similar to that of the webbing clothes moth. Unlike the webbing clothes moth this species covers its body with a portable silken case. Once covered the entire larval period is spent within, and the case is dragged behind as new feeding areas are sought. The case is often composed of dried fibers interwoven with silk, creating a multicolored effect.

Table 5. Identification of Clothes Moths

Species	Larval Feeding Damage
 Webbing clothes moth Tineola bisselliella **Adults** Wings uniformly golden or buff colored.	Larvae spins webs freely over feeding surface and produces tunnels or tubes for protection. Copious amounts of fecal material scattered throughout feeding area.
 Case making clothes moth Tinea pellionella **Adults** Brown with 3 dark spots on each forewing.	Entire larval stage spent in case, case dragged behind larvae as new feeding areas sought. Case covered with fecal pellets or bits of woolen fiber.
 Carpet moth Trichophaga tapetzella **Adults** Basal 1/3 forewings black, outer portion mottled white, black and gray.	Similar to webbing clothes moth. Feeding damage frequently extend deeper into materials.

Also unlike the webbing clothes moth, this species does not spin copious webbing over its food material. This species eats out well defined, clean cut holes. When the larval feeding is completed, it frequently crawls up on vertical surfaces to pupate; consequently, it may be found on walls, partitions or other similar structures when pupating. Pupation occurs in the larval case.

Table 6. Identification of Carpet Beetles

Species	Diagnostic Characteristics
 Black carpet beetle Attagenus megatoma	Adults distinctly oval, dark brown to black, about 1/6 inch long. Larvae carrot-shaped with long tail bristles. Shiny brown to black.
 Varied carpet beetle Anthrenus verbasci	Adults slightly oval shaped and mottled with white, brownish, and yellowish scales. No cleft at tip of wings. Larval body wedge-shaped with rear broader than head. Three tufts of hair on either side of rear end.
 Furniture carpet beetle Anthrenus flavipes	Adults mottled with yellow, black and white, more rounded than varied carpet beetle, cleft at tip of wings. Larvae torpedo-shaped, head wider than rear, darker than varied carpet beetle.
 Carpet beetle Anthrenus scrophulariae	Adults round-oval, about 1/8 inch long, black with orange red scales, scalloped band of orange down center of back. Larvae reddish brown, hair extending outward from entire body.

CARPET MOTH

The carpet or tapestry moth is not commonly encountered in the United States but can occasionally become established and cause considerable damage to heavy fabrics and pelts. The larvae normally feed in silk-lined burrows within the infested material. Damage is caused by both feeding and severing of fibers which are used in construction of the burrows. There are usually 2 to 3 generations per year.

BLACK CARPET BEETLE

This is a serious fabric pest in the eastern states. In these areas, it is considered the most destructive of all carpet beetles. It is also common in the western states. The larvae are extremely active feeders and will readily burrow and enter food or food containers that are not perfectly sealed. The searching habits of the larvae frequently result in their appearance in containers of non-food materials. Dead bodies of insects are the preferred food of this species. For this reason, black carpet beetles are frequently found in cereals and grain that are infested with stored product pests.

Black carpet beetle infestations that are found in homes and industry frequently begin with a buildup of the population in bird nests, abandoned wasps or bees nests and dead rodent bodies that are located in attics, chimneys, wall voids or basements. Larvae initially located in these situations will freely migrate into the living quarters of the building and infest any suitable food materials.

Under ideal environmental conditions this species requires about 1 year to complete a generation. The larvae will pass through 6 to 20 molts and may require up to 650 days complete development under poor environmental conditions. The last larval instar typically does not pupate until encountering suitable environmental conditions. Pupation typically occurs in protected situations.

FURNITURE CARPET BEETLE, VARIED CARPET BEETLE, CARPET BEETLE

These 3 beetles belong to the same genus (Anthrenus) and are similar enough in appearance and habits that they should be considered together. The Anthrenus carpet beetles feed on the same type of materials as the black carpet beetle. They are omniverous and feed on many types of plant and animal matter. The feeding behavior of the Anthrenus species is distinctly different than that of the black carpet beetle. None of these 3 beetles burrow in their food material. As a result they are more frequently encountered as surface feeders. A heavy infestation will show many larvae feeding in close proximity to each other on the surface, but feeding deeply enough to penetrate woolen fabric and other materials.

The varied carpet beetle passes through about 1 generation per year. The larvae passes through 5 to 16 larval instars. The female lays an average of 30 eggs. With 1 generation per year and an average of 30 eggs per female, this species potential capacity for rapid reproduction and infestation is limited.

The life cycle of the furniture carpet beetle may be complete in as little as 3 months. Under ideal conditions, this species may complete up to 4 generations per year although in the home 2 per year is the more likely situation. The females lay an average of 70 eggs each. This species is extremely destructive to carpeting, upholstered furniture, clothing and natural fiber brushes.

The carpet beetle, which has also been known as the buffalo bug, seems to be less common in the eastern part of the United States. It is still a common fabric pest east of the Rocky Mountains. The carpet beetle is capable of completing 1 generation in 78 days although the average is closer to 3 months. Thus 1 pair of carpet beetles are capable of producing several thousand offspring in a 1 year period.

Control

Control methods for fabric pests can be divided into 2 distinct categories: prevention and elimination. Prevention is usually limited to the public. However, the pest control operator should be aware of these techniques and can function to recommend sanitary methods that reduce the chances of initial infestation and eliminates conditions that favor the development of populations in the home or industry. The following technique will minimize the chance of establishment of these pests.

1. Do not store soiled or contaminated wool garments.
2. Do not allow unwanted soiled woolen garments to accumulate in protected locations.
3. Do not allow lint or dust to accumulate in undisturbed areas.
4. Do not keep furs, feathers or woolens in storage without moth protection.
5. Woolens and other fabrics should be tightly wrapped with such repellents as paradichlorobenzene or napthalene (moth balls). Caution should be taken to sandwich these volatile substances between sheets of paper to prevent staining of these fabrics.

Elimination is the major phase of fabric pest control which can be offered by the pest control industry. Elimination may be effected in part by the use of sanitary methods, but basic reliance must be placed on killing the existing pests with contact and or residual chemical.

Difficulty arises due to deep-seated infestations occuring deep within carpeting or beneath or behind other infested materials. Water emulsion or even oil base sprays too often fail to reach hidden insects as wool repels small droplets of spray. Spray equipment must propel the insecticide droplets sufficiently to force them beneath the surface of fibrous materials in carpeting. The "furry" nature of the varied and furniture carpet beetle larvae, plus natural resistances of the black carpet beetle, also tend to protect these insects against most aqueous sprays. The use of wetting agents in both oil and water sprays greatly improves penetration.

Carpeting should never be "soaked" with an oil spray. Penetration should be deep enough to reach the base pile but not enough to wet the synthetic or rubberized backing, otherwise "warping" may occur. A means of assuring rapid penetration and evaporation of oil spray without damage to the carpet backing is to cut base oil by one-half with isopropol alcohol (rubbing alcohol). For the first few moments following treatment with this combination, flash point is lower and odor higher; however, both undesirables dissipate quickly in a well ventilated room. Insecticidal deposit is thus evenly distributed throughout all fiber, reaching the seat of infestation. Rapid evaporation also enables quick resumption of traffic on treated carpeting without tracking dirt on or oil off the carpet. It is not necessary to treat an entire wall to wall carpet that is walked upon and vacuumed regularly. Attention should be given to areas under stationary furniture, or around heat registers.

INSECT PESTS OF STORED PRODUCTS

There are over 100 species of insects found infesting dried plant and animal food materials. Exclusive of the cockroaches, mites and ants, the majority of these pests belong to the orders Coleoptera (beetles) and Lepidoptera (moths). The occurance of these pests in homes, restaurants or other structures usually originate from 1 of 2 sources. The majority of these pests originate from infested material brought into the residence. This typically results when food materials are first stored for a period of time in an area, such as a warehouse, where an infestation already exists. Once a pest is introduced, it may readily spread to other suitable foods in the structure. Some infestations may also originate from the small numbers of these pests that naturally occur in and around areas where food is stored.

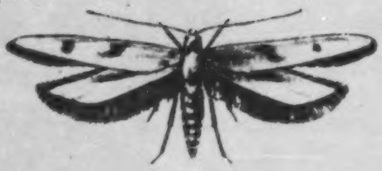
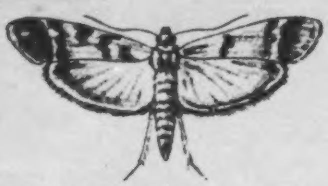
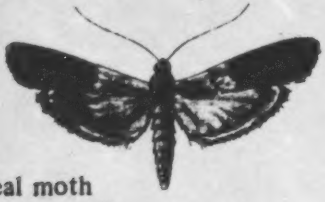
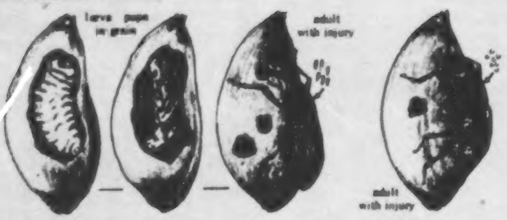
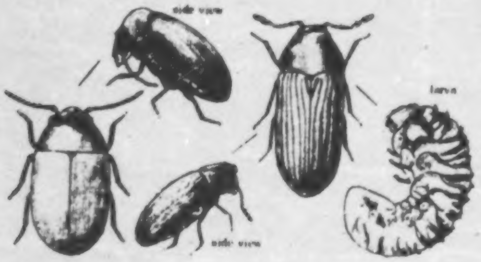
Most stored product insects are cosmopolitan or worldwide in distribution. One reason for the wide distribution of these pests is that grain, cereal and other dried foods and their pests have been shipped with little restriction all over the world. Another reason may relate to the environmental conditions in stored products. An important factor influencing the distribution of any insect species is the range of environmental conditions within which it is capable of living. As the reader might expect, an insect that is capable of surviving in one geographical area, will not be capable of surviving in another area if environmental conditions are not suitable. Like other insects, stored product pests have a limited range of environmental conditions within which they are capable of moving, feeding and reproducing. However, unlike insects that develop outdoors, stored product insects are not normally exposed to the extremes in different climatic conditions of different geographical localities. For example, while the climates of Southern California, Canada, Russia and France differ immensely, environmental conditions in a grain silo, home or warehouse in each location are likely to be similar.

It is beyond the scope of this text to attempt to discuss all the pests of stored products. We will limit our discussion to the 10 most commonly encountered pests in the orders Coleoptera and Lepidoptera. The cockroaches, mites and ants are discussed in other sections of this text.

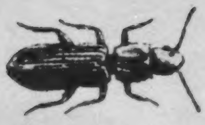
Identification

The beetles and mites develop with complete metamorphosis. Generally the life cycle of stored product pests is short and the egg, larval, pupal and adult stages of any pest will all be present at the same time in a well established infestation. This is very convenient for identification purposes. It is almost impossible to identify any of these species with either the egg or pupal stage. The larval stage can be used in identification, but this usually requires considerable expertise and should be avoided if possible. It is easiest to base identification of the stored product pests on the adult stage. Since many of these pests are small, it may be necessary to use a 10X eyepiece magnifying glass in identification. It should be noted that the identifying characteristics given in Table 7 are only useful if the pest is found in stored products.

Table 7. Identification of Adult Stored Product Pests

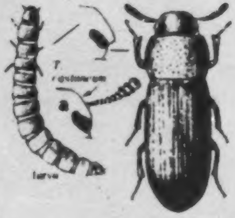
Pest Species	**Identifying Characteristics**
 Angoumois grain moth *Sitotroga cerealella*	Wingspread 1/2 inch. Pale yellow forewings. Gray hindwings which are pointed at end resembling a pointed finger.
 Mediterranean flour moth *Anagastra kuehniella*	Wingspread 3/4 inch. Front wings gray with wavy transverse bars. When at rest head and thorax raised above abdomen protruding between and above wings.
 Indian meal moth *Plodia interpunctella*	Wingspread 3/8 inch. Basal 1/2 forewing grayish with outer 1/2 inch as well as head and thorax reddish.
 larva pupa in grain adult with injury adult with injury Rice weevil *Sitophilus oryzae* Granary weevil *Sitophilus granarius*	Length 1/8 inch and dark brown in coloration. Mouthparts drawn into elongate snout or beak.
 Drugstore beetle* *Stegobium paniceum* Cigarette beetle *Lasioderma serricorne*	Squat, 1/8 inch in length and reddish brown in coloration. Head retracted into thorax and not visible from a dorsal angle. Elytra of cigarette beetle with parallel lines. Drugstore beetle elytra smooth.

*These 2 beetles are very similar in appearance and have similar biologies.



Saw-toothed grain beetle
Oryzaephilus surinamensis

Approximately 1/8 inch long, elongate, dark brown and flat. Readily recognized by 6 saw-toothed like projections, located on the lateral margins of each side of thorax.



Confused flour beetle
Tribolium confusum
Red flour beetle
Tribolium castaenum

Elongate, flattened, shiny reddish brown and about 1/8 inch in length. Antennae gradually enlarged to form a club.

Biology

The feeding habits of stored product pests can be divided into 2 large categories. These are external and internal feeders. As one might expect, the external feeders will feed on the exterior of stored foods while the internal feeders bore into the food and may spend the larval, pupal or even part of the adult stage within the food. In many cases the actual amount of food consumed by a stored product pest may only be a minimal part of the damage. Some of the moth species web their food with silk. In heavy infestations, this webbing may actually clog the machinery used to process the food (e.g., flour mills). Also, governmental agencies have set limits on how much insect contamination may be present in processed food. For example, if infested grain were ground into flour, the flour may be judged unfit for human consumption if it exceeded the allowable amount of insect contamination. In this case, the contamination would be ground insect parts which were not detectable to the human eye.

Generally speaking, insects found infesting stored products will not harm animals or man if consumed. Indeed, they actually add an additional source of protein to the diet. However, the average consumer will find a few beetles in his cereal extremely repulsive and will discard this and any other infested material in the pantry. The damage caused by stored product pests is often enhanced by the mind of the consumer.

Specific biological facts about the common stored product pests are presented in Table 8.

Control

Packaging usually has little effect preventing stored product pests from infesting food. Most methods of packaging food can be invaded by stored product pests. Cardboard, cellophane, metal foils, various cloths and most flexible plastics are readily penetrated by the larval, adult or both stages of these pests. Metal cans and tightly sealed glass containers are generally secure. Since most packaging is penetrable, once these pests become established in an area, they will typically spread to other food materials in the structure.

The first step in control is to locate and destroy the source of the infestation. However, the bulk of the infested material is usually confined to a small area, such as a closet or cabinet in the kitchen. Once the source of infestation is located and destroyed, all penetrable food containers, sealed or not, should be inspected. Foods such as cereals, nuts, beans, peas, spices, dried bread and fruits should be checked with care. Once all suspect food is removed, the storage cabinets, pantries or other areas of storage should be thoroughly cleaned, paying particular attention to crevices. A vacuum cleaner can be used to pick up loose food particles and dirt. These areas should then be washed with soap and hot water and allowed to dry.

Chemical application is frequently very helpful. It is essential that insecticides, whether residual or space sprays, be kept from direct contact with food products. The chemical should be applied to all the shelves, drawers or benches in the general area of infestation. After the insecticide is

Table 8. Biology of Stored Product Pests

Pest Species	Feeding Damage	Developmental Biology	Food Infested
Angoumois grain moth *Sitotroga cerealella*	Very important grain pest in South. Commonly found emerging from decorative corn in home. Internal feeder.	40 – 400 eggs per female. Six to 7 generations per year. Larval and pupal stage found within host.	Mainly attacks whole grain.
Mediterranean flour moth *Anagastra kuehniella*	Larvae spins large amounts of silk in and over food. Surface feeder.	360 – 600 eggs per female. Three to 4 generations per year. Larvae typically leaves area of host to pupate.	Prefers flour, also infests wheat, bran, nuts, chocolate, seeds, beans, dried fruits and others.
Indian meal moth *Plodia interpunctella*	Larvae spins large amounts of silk in and over food. Most commonly encountered food infesting moth in home and grocery store. Surface feeder.	40 – 400 eggs per female. Five to 6 generations per year.	Same host range as Mediterranean flour moth.
Rice weevil* *Sitotroga oryzae* Granary weevil *Sitotroga granarius*	Most important whole grain infesting insects in world. Internal feeder.	50 – 400 eggs per female. Six to 8 generations per year. Larvae and pupae found within host.	Attacks whole grain or pieces of grain large enough for larvae to develop within.
Drugstore beetle* *Stegobium paniceum* Cigarette beetle *Lasioderma serricorne*	Most common pantry pest in United States. External feeder.	20 – 200 eggs per female. Six generations per year.	Very general feeders, attacking almost all dried plant and animal including drugs and tobacco.
Saw-toothed grain beetle *Oryzaephilus surinamensis*	Feeding consists of scarring and roughening of surface of food. Very common household pest.	50 – 300 eggs per female. Eight to 9 generations per year.	Very general feeding. Attacks almost all dried plant products.
Confused flour beetle* *Tribolium confusum* Red Flour beetle *Tribolium castaenum*	Feedings consists of scarring and roughening of surface of food. Usually brought into home in flour.	400 eggs per female. Six to 7 generations per year.	Common in flour, also infests cereals, nuts, chocolate, spice, peas and many others.

*These 2 beetles have almost identical life.

allowed to dry, the sprayed surface should be covered with paper or other material to avoid having food or food containers come in contact with the residue. It may take several days for the insects to contact the residue and be killed. Fumigants are also commonly used in controlling stored product pests, especially in warehouses and other large scale operations.

DOMESTIC FLIES

The order Diptera (flies) is one of the largest and most diverse in the class Insecta. There are close to 17,000 species of flies in North America. Most of these flies are rarely encountered by man and are of little concern. A rather small group, which we shall term domestic flies, have evolved to live in close association with man. These flies are typically found around or within structures and can become extremely annoying by their constant presence and ability to bite and transmit diseases. This section is concerned with 9 kinds (about 20 species) that are important nuisance flies in the United States.

Identification

There is little or no information available on the identification of domestic flies based on the egg or pupal stage. The larval stage may be used for identification, but this is frequently difficult. Table 9 presents a synopsis of identifying characteristics of the common adult domestic flies.

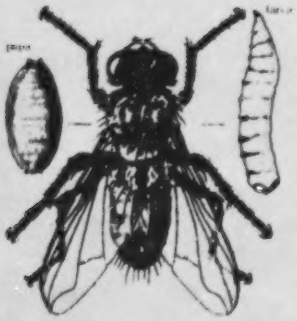
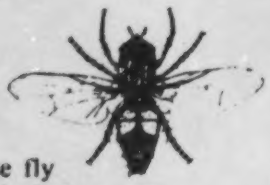
Biology

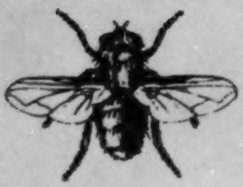
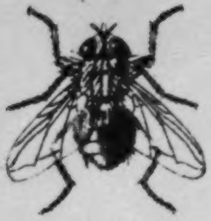
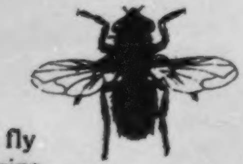
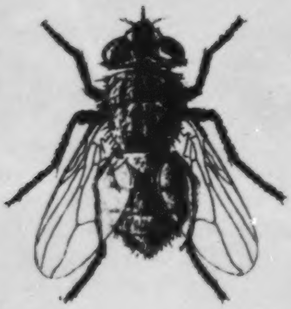
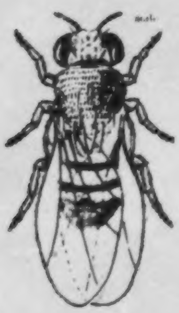
The life cycle of each species of the domestic flies is quite similar. The immature stages are found in moist, solid organic matter which is usually associated with man's activities. The female deposits small (approximately 1/25-inch long), white eggs in or upon the host material. The eggs typically hatch in a day or less and are extremely susceptible to desication. The white, legless carrot-shaped larvae may reach 1/2- to 3/4-inch in length. When preparing to pupate, the larvae move to drier areas of the host material.

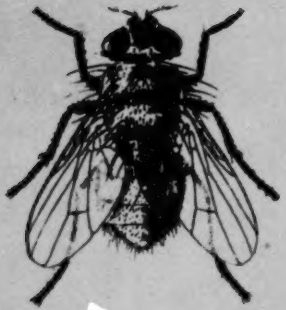
The pupa can be recognized by the hard, brown pupal case in which the larva transforms into an adult. Empty pupal cases may be found in the host material long after an infestation has ceased and are not necessarily a sign of an active infestation.

The developmental period of the domestic flies is relatively short compared to other insects. The house fly, under favorable environmental conditions, is capable of developing from egg to adult in as little as 7 days. The cycle of the other domestic flies may be completed in as short as 8 to 18 days depending on the species. This short life cycle coupled with the ability of the female flies to lay large numbers of eggs gives these pests a tremendous reproductive capacity. Under favorable conditions, large numbers of these flies can appear in a very short period of time. The specific biologies of the domestic flies are presented in Table 10.

Table 9. Identification of Adult Domestic Flies

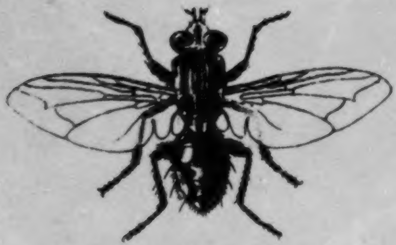
Species	Identifying characteristics
 House fly Musica domestica	Dull gray with 4 stripes on thorax. Abdomen lighter color than thorax. Fourth longitudinal vein sharply angled. Body 1/4 inch in length.
 Little house fly Fannia canicularis	Males easily recognized by habit of hovering in protected places. Dull gray with abdominal segment next to thorax yellow. Similar in size to house fly, but less robust.

Species	Identifying Characteristics
 Green blow fly Phaenicia (2 species)	Shiny green or copper colored. Slightly larger and more robust than house fly.
 Blue blow fly Eucalliphora and Calliphora (several species)	Bicolored, the thorax gray with stripes and abdomen shiny blue. About size of green blow fly.
 Black blow fly Phormia regina	Shiny black or green and similar in size or slightly larger than house fly. Distinguished from green blow fly by presence of orange anterior spiracle.
 Stable fly Stomoxys calcitrans	Similar in size to house fly, but has elongate blood sucking mouthparts. When at rest, body slightly angled rather than parallel to surface.
 Vinegar fly Drosophila (several species)	Small (1/8 inch), yellowish brown. Typically found hovering around overly ripe or decaying fruits and vegetables.



False stable fly
Muscina stabulans

Similar to house fly but can be distinguished by pale or reddish color on tip of scutellum and the fourth longitudinal vein only slightly curved upward near tip of wing.



Flesh flies
(several genera)

Dull gray. Only 3 black stripes on thorax. Abdomen usually has a checkered pattern. Males of many species with red spot on tip of abdomen. Generally larger than house fly.

Control

The basis for domestic fly control is the elimination or prevention of favorable habitats for fly production. If suitable habitats exist and environmental temperatures are favorable, a domestic fly problem will undoubtedly result. The use of insecticides is only secondary in fly control. Habitats where flies breed frequently cannot effectively be reached or penetrated by insecticides. Insecticide treatment at locations other than the site of breeding and development is at best a temporary means of control.

Some of the fly problems in urban areas and most of the problem in rural areas originate at sites other than in the immediate vicinity of homes, restaurants and similar structures. However, most flies live within 1/2 mile of where they hatch and rarely do large numbers of flies travel more than 2 miles. Nevertheless, if a large population exists around a structure, it is advisable to consider all possibilities of their origin. Common agricultural areas where large fly populations may breed include chicken ranches, dairies, beef feed lots, hog ranches, horse stables and areas of crop production where manure is used or fruits and vegetables are culled. Control or prevention of fly population in these areas is beyond the scope of this text. Adequate information is available and can be obtained from local farm advisors or state agricultural agencies.

Fly control in the urban areas follows the same principles as that in the rural areas. That is, locate the breeding place or places of the population and eliminate them. The first step is to identify the pest species. In many instances this will limit the potential breeding localities. For example, if a large number of blue blow flies are present, the operator should first expect some animal carcasses in the vicinity. Once a breeding site has been eliminated, corrective steps should be taken to prevent a recurrence of the problem. Possible breeding areas for domestic flies are outlined in the following discussion.

1. Garbage cans are probably the single most important source of domestic fly production. Tight fitting lids may be of some value. Also, twice a week garbage collection and a thorough cleaning of the cans is very helpful.
2. Grass clipping may be an important source of fly production if piles are allowed to accumulate and decompose until the inner areas reach a slimy stage. If clipping piles are removed every other week, this should not be a problem.

Table 10. Biology of Domestic Flies

Species	Life cycle	Adult occurance	Preferred host material
House fly Musica domestica	200 – 2000 eggs per female. Egg to adult in 7 to 45 days.	Prefer warm but not too hot weather. May occur year around but most abundant in Sept. and Oct.	Larvae almost always occur in man-made sources, animal waste, culled fruits and vegetables are preferred.
Little house fly Fannia canicularis	180 – 560 eggs per female. Egg to adult in 18 to 24 days.	Males typically hover in protected locations such as garages, porches and inside houses. Less abundant during summer and winter.	Larvae develop in almost all kinds of decaying organic matter. Chicken maure usually the source of large infestations. Other types of manure also favored.
Green blow fly Phaenicia (2 species)	3000 eggs per female. Egg to adult in 9 to 18 days.	Frequently most common flies in urban situation. Common during summer months.	Garbage cans common source during summer months. Dog droppings also preferred.
Blue blow fly Eucalliphora and Calliphora	500 – 700 eggs per female. Egg to adult in 15 to 21 days.	Usually first flies to appear in the spring.	Decaying carcasses of birds and mammals. Also found in garbage dumps.
Black blow fly Phormia regina	200 – 400 eggs per female. Egg to adult in 10 to 25 days.	Most common blow fly in wild areas. Active in relatively cool temperatures in spring and summer.	Decaying carcasses. Also lays eggs in open wounds of animals
Stable fly Stomoxys calcitrans	200 – 400 eggs per female. Egg to adult in 13 to 40 days.	Common around dairies. Occasionally attracted to and bite dogs in large enough numbers to be a problem.	Manure, especially when mixed with straw. Lawn clippings and animal feed waste also preferred.
Vinegar flies Drosophila (several species)	400 – 1000 eggs per female. Egg to adult in 8 to 11 days.	Most abundant around larval source and during fall, but can be present year around.	Larvae found in decaying fruit and vegetables. Garbage cans frequent source.
False stable fly Muscina stabulans	140 – 220 eggs per female. Egg to adult in 15 to 30 days.	Most abundant in early spring prior to peak house fly emergence. Occur in many situations.	Manure and decaying plant waste such as culled fruit.
Flesh flies (several genera)	Female deposits 30 to 60 larvae instead of eggs. Eggs held in female until they hatch. Larvae to adult 8 to 18 days.	Year around, more common in warm months.	Garbage cans, manure (especially untrampled) animal carcasses including snails.

3. Dog and cat droppings may sustain a fly population if they are allowed to accumulate. These materials may not only serve as a source of an infestation, but droppings also serve to attract many flies into an area in larger numbers than normal.
4. Fertilizers (especially chicken and cow manure) may contain fly larvae which emerge after the fertilizer is applied, or flies may actually go through a complete life cycle after the manure is applied if it is not thoroughly mixed into the earth.
5. Dead snails are frequently a source of fly infestation, especially for flesh flies. Accumulations should be removed once a week.
6. Compost piles may produce flies if they are not turned frequently and kept sufficiently dry.

DOORYARD PESTS

Dooryard pests refer to many animals that typically live outside of structures and occasionally invade buildings. A few of these pests are capable of causing extensive damage within the home. In most cases they are simply a nuisance pest because of their presence. The common dooryard pests and their control are discussed in the following section. Since control methods for the sowbugs, pillbugs, millipedes, centipedes, Collembola and earwigs are very similar, they are discussed as a unit.

SOWBUGS AND PILLBUGS

Sowbugs and pillbugs are Crustaceans and not insects. These arthropods are extremely common in many areas of the United States and are worldwide in distribution. Mature sowbugs and pillbugs have 7 pairs of legs, are oval-shaped, segmented, brown to grayish in color and measure up to 3/4 inch in length (Fig. 25). Pillbugs, as their name implies, are capable of rolling up into a tight ball or pill. Sowbugs cannot roll into a ball and further differ from pillbugs by the presence of 2 prominent tails like segmented appendages.

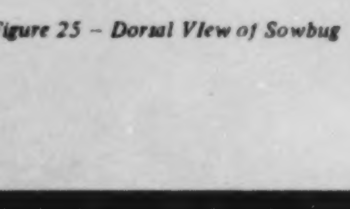


Figure 25 – Dorsal View of Sowbug

Sowbugs and pillbugs breathe by means of gills; hence, they require considerable moisture to survive. Some species are capable of surviving up to one day or more under extremely dry conditions; however, most will burrow into the soil if adequate moisture is not available.

These arthropods mainly feed on decaying vegetable matter. They may do some damage to seedling plants and are readily attracted to strawberries, grapes or any other overly ripe fruit in contact with the ground. When large populations are found around the home, this is usually associated with accumulations of leaf litter, grass clippings, stacked wood, excessive mulch in flower beds, or other situations where adequate food and considerable moisture is present. Under these conditions, sowbugs and pillbugs may enter damp basements and lower areas of the home.

Breeding can occur throughout the year, but typically occurs during the spring months. The eggs, and newly hatched young average from 25 to 35 per brood and are carried in a pouch on the under side of the body. The newly hatched young are white in coloration and remain in the brood sac until approaching the first molt. There may be up to 20 molts, and it may require a year or more to reach adulthood.

MILLIPEDES

The millipedes are worm-like arthropods having many legs arranged 2 pairs each on most body segments. The body may range from 1/2 to 6 inches in length and consists of a head, 4 thoracic segments and from 16 to 30 more abdominal segments. Their antennae are short and the mouthparts are comb-like (Fig. 26). These arthropods are sluggish and will characteristically roll up into a ball when disturbed.

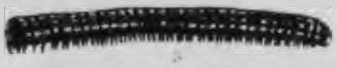


Figure 26 – Millipede

Little is known about the biology of millipedes. The female typically lays from 20 to 30 eggs as a cluster in the soil. The newly hatched young has 3 pair of legs in most species. There are typically 7 to 10 molts with the number of legs and segments increasing with each molt. It may require from 2 to several years to reach maturity. Adults typically live several years.

Decaying organic matter is the preferred food of millipedes. They are occasionally pests of germinating seeds, bulbs and roots but seldom cause enough damage to justify control. Small numbers of these pests can usually be found around the home, under rocks, in leaf litter, lawns, planters and any other area having adequate moisture and food. In these situations millipedes rarely enter the home and should not be treated.

However, under ideal conditions, these anthropods may build up to tremendous numbers. Large numbers of millipedes are usually associated with large amounts of decaying vegetable matter such as leaves, logs, brush, mulch and or grass in combination with ample moisture. Favorable weather conditions, usually mild winters, allow better survival and hasten development. Millipedes may migrate into the home in large numbers when environmental conditions become less favorable such as a lack of food, dryness or flooding. Because of their relatively large size, these pests are generally of considerable concern to the home owner.

CENTIPEDES

The centipedes are elongate, flattened, wormlike arthropods with 15 or more pairs of legs. They have 1 pair of legs per body segment with the last pair elongated, directed backwards and often different in form than the others. The appendages of the first body segment behind the head are fang-like, held beneath the head and function as poison jaws (Fig. 27). Unlike the millipedes, centipedes do not roll up into balls when disturbed.

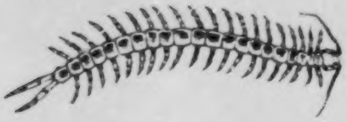


Figure 27 – Centipede

Centipedes live outdoors in a variety of habitats such as under bark, rocks, boards, or in rotten logs and leaf litter. They are predatory and feed on insects, spiders and other animals. The poison jaws function to inject a toxic saliva and paralyze their prey. The smaller centipedes in the northern states are harmless and do not readily bite; however, the larger species in the south and tropics are capable of inflicting a painful bite. These arthropods are not normally found within structures, but because of their fearsome appearance and relatively large size, when they accidentally gain entrance, they are of immediate concern. Larger species may range up to 6 or 7 inches in the southern areas of the United States and to over a foot in the tropics.

A very common species found in the home throughout the United States is the common house centipede, Scutigera coleoptrata (Fig. 28). The body of this arthropod is a little over an inch in length. However, the legs are greatly elongated and make this centipede look much larger than it is and extremely fearsome. Despite its frightful appearance, this species does not readily bite and when it does it has difficulty penetrating the skin. This species is found both outdoors and in the home.

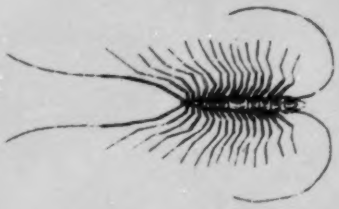


Figure 28 – Common House Centipede

Centipedes develop with simple metamorphosis. They typically overwinter as adults in the soil. In the summer, the eggs are deposited singly in loose soil. The eggs are sticky and quickly become coated with debris. Many species of centipedes stay with and protect the immature stage. In some species the male adult will eat the eggs before the female can get them covered with dirt. Some species may live up to 6 years.

SPRINGTAILS

The springtails are a primitive group of insects that on occasion may be of some concern to the home owner. They are delicate, wingless, soft bodied insects that typically measure less than 1/16 inch in length. The next to last segment of the body bears a forked appendage called a furcula. This structure can be pulled under the abdomen and released in a spring-like fashion enabling the insect to jump several inches. The color of the adults may vary from white to pink to blue (Fig. 29).

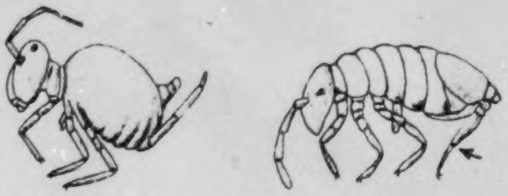


Figure 29 – Springtails

These arthropods have ametabolous development. Although these are among the most common and universally distributed of all insects, relatively little is known about their life history. Springtails may pass through several generations a year and can build up to tremendous numbers in a short period of time. Large populations are typically encountered during the late spring months when temperatures are warm and moisture is plentiful.

These insects feed on decaying plant and animal matter, fungi, algae, bacteria and living plants. They may become pests in mushroom cellars, occasionally damage greenhouse plants and destroy germinating seeds. However, unless populations are large and conditions are ideal, the feeding of springtails is rarely a problem.

Adequate moisture is critical to springtail development. Common habitats include leaf litter, under loose bark, in lawns or any other areas associated with decaying organic matter. Springtails may breed in a variety of conditions including flower pots, planters, in basements, around kitchen sinks and similar areas. Massive numbers of these pests may emerge from lawns in the spring and become a temporary pest around swimming pools.

EARWIGS

Earwigs are a common group of insects that are characterized by a flattened elongated, parallel sided body and a pair of forcep-like appendages on the end of the abdomen (Fig. 30). Some species are wingless, but others have a short pair of leathery forewings covering the first few abdominal segments. These insects are generally brown to reddish brown in coloration and range from 1/4 to 1/2 inch in length. The pinchers are typically larger and more curved in the males than the females. Although the pinchers are well developed in most species, they are incapable of penetrating the skin. These structures are used in courtship and defense.

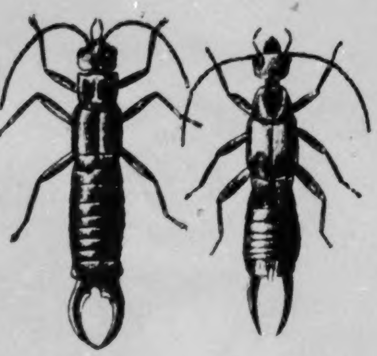


Figure 30 – Earwigs

Earwigs develop with simple metamorphosis. The female typically forms a hollow nest 2 to 3 inches below the surface of the ground or beneath rocks, logs or other debris. Most species exhibit some social tendencies. The female stays with and guards the eggs and first larval instars. She periodically cleans and grooms the egg to prevent the buildup of fungi. After the first molt, the immature stage leaves the nest. Most species have about 1 generation per year and overwinter in either the egg or adult stage. During the day the nymphs and adults can be found under logs, rocks, boards, beside sidewalks, in leaf litter and other similar locations. Most species are active and forage at night, chiefly feeding on decaying organic matter, various plant parts and dead insects. Some species are predatory and feed on earthworms and other insects. A few species are of economic significance as greenhouse, garden, and agricultural pests.

Earwigs are typically outdoor species; however, a few may occasionally enter the home, especially during warm weather. They typically do not feed or breed within structures, but because of their relatively large size and fearsome looking forceps, they are of considerable concern to the home owner.

Although there are over 20 species of earwigs in the United States, only a few of these wander into structures in large enough numbers to be of importance. The European earwigs (Forficula auricularia) is the most widespread of the common earwigs occuring from the west to the east coast of the United States and southern Canada. This species readily attacks garden and vegetable crops, where it eats flowers and foliage of many plants such as seedling vegetables, dahlias, carnations, chrysanthemums, lettuce, celery, marigolds and potatoes. However, most objections still arise from its habit of entering homes.

Control

Control of the sowbugs, pillbugs, millipedes, centipedes, Collembola and earwigs is sufficiently similar that it can be considered as a unit. Sanitation is the key to preventing these pests from reaching pest status. In this case, sanitation includes the removal of decaying vegetable matter and the reduction of available moisture. In many cases, this step alone will suffice to reduce the nuisance effect of these arthropods. Entrance into the home can be greatly reduced by adding weather stripping to doors and windows and sealing all cracks and crevices to the outside.

In some cases, if the problem is persistent, chemical treatment may be necessary. Chemical treatment must occur outside the home to achieve any degree of permanent control. Generally speaking, wettable powders or emulsifiable concentrates of residual chemical are preferred. Sprays should be applied in a 2 to 3 foot strip around the entire foundation. Suspected breeding sites should also be treated. In the latter case, the insecticide should be applied with enough water to carry it down into the habitat of the pest.

FIELD CRICKET

Field crickets (acheta assimilis) have large heads, long thread-like antennae that extend up to 1/2 inch past the tip of the abdomen and a spear-like ovipositor in the females. The hind legs are well developed for jumping. The adults vary considerably in color, ranging from dark brown to gray to black, and body length, from 3/5 to 1 inch (Fig. 31).

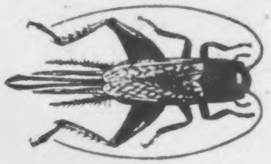


Figure 31 - Field Cricket

The field cricket is found throughout the United States, southern Canada and much of South America. Besides being a dooryard pest, this is of considerable importance as an agricultural pest. In many states, they damage cotton by severing seedling plants immediately above ground level. They are also of considerable importance as a pest of alfalfa, tomatoes, cucurbits, peas, beans, strawberries and others, feeding mainly on the fruiting bodies of these crops.

The life cycle of the field cricket varies considerably throughout its range. In northern areas they winter in the egg stage within the ground and typically produce 1 generation per year. In southern areas, they winter as nymphs or remain active throughout the year and may have as many as 3 generations per year. The total developmental period in the summer months occupies from 9 to 14 weeks. Mature females deposit an average of 300 eggs each, preferably in damp soil.

The field cricket causes most problems to the home owner in the adult stage. In many areas, massive numbers of adults develop in the late summer. These adults fly, frequently moving out of agricultural areas and are attracted readily to lights around homes, gas stations, supermarkets, motels and any other illuminated area. Outside they are mainly a pest because of their large numbers. It is not uncommon for the area beneath street lights to become slippery where cars have crushed massive numbers of these pests. They may occasionally feed on ornamental plants around the home, but most feeding damage results when the cricket enters the structure. They frequently eat holes in paper and rubber and in cotton, linen, woolen or fur garments, especially when these are soiled with perspiration or food. Even nylon, wood, plastic and leather goods can be damaged.

Control

Sanitation may be of some value depending on the extent and source of the infestation. Removal of trash piles and tall weeds is worthwhile prior to chemical treatment. If dumps or similar areas are breeding sources for large populations of crickets, a 6-inch covering of soil or ashes will destroy and prevent these infestations.

Many problems may be eliminated if extraneous lighting is eliminated during heavy flights of this pest. If heavy populations are present, it may be necessary to spray entire yard areas, especially true if the crickets are breeding in agricultural areas and flying to lights in residential areas. Outdoor applications in residential areas under these circumstances is at best a very temporary means of control. If crickets enter structures, residual sprays can be applied to baseboards, in closets, under stairways, around fireplaces and other areas where they have been observed.

BOOKLICE

The booklice are small, soft-bodied insects, most of which are less than 1/4 inch in length. Some outdoor species have wings, but home-infesting species do not. Booklice have chewing mouthparts, elongate antennae and the clypeus (upper lip) is large and somewhat swollen (Fig. 32). They are usually almost colorless when young, but obtain some coloring when mature, possibly originating from their food. Living specimens can usually be recognized by their small size and erratic movements when running.

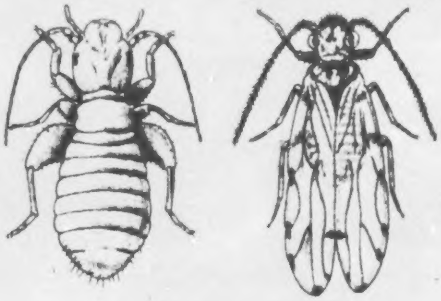


Figure 32 - Booklouse

There are over 150 species of booklice in the United States, but only a few are normally encountered in the home and industry. These indoor species feed mainly on fungi and live in humid environments. Large populations may build up in new housing tracts. This is chiefly due to the use of green lumber which may be built in wall voids, attics and other enclosed situations. This usually results in sweating, high humidity and the development of fungi. These infestations soon become widespread within the building; however, as soon as the building is heated, the situation is dried out and reinfestation seldom occurs.

Localized infestations may result from leaky roofs and plumbing, damp basements and crawl spaces. Several species of booklice are also associated with and feed upon bird nests, bee and wasp nests, paste in book bindings, dead insects and various cereal products.

Booklice develop with incomplete metamorphosis. The females lay an average of 60 eggs singly in cracks or crevices. One generation may be completed in as little as 35 days, but it would be much longer at lower temperatures. Adults are relatively long-lived and may survive for several months. Most indoor species readily avoid light and prefer temperatures of 75 to 85°F and relative humidities of 70 to 90%.

Control

Sanitation is the first step to booklice control. In this case, sanitation refers to the removal or elimination of sources of excessive moisture. If infestations are widespread, it is likely that the source of infestation is originating within wall voids or other enclosed situations. In this case little can be done, but it should be emphasized that this situation will be rectified when the heat is turned on in the fall. If bird nests, cereals or cereal products, or other vegetable matter is the source of infestation, these should also be removed and destroyed.

Chemical control mainly consists of applying residual insecticides to the infested areas. Preferably the chemical used should not be readily inactivated by high amounts of moisture. If the infestation is widespread within the wall voids, these chemicals can be applied around baseboards, window sills and other areas where the booklice emerge from the walls.

JERUSALEM CRICKET

(Stenopelmatus fuscus)

This insect is also known as the potato bug or sand cricket and is widely distributed in the western United States. These insects can readily be recognized by their rather grotesque appearance. They are large, ranging from 1 to 2 inches in length, and have a large, shiny tan to brown head. The legs are well developed and armed with stout spines on each tibia, an adaption for digging. The abdomen is large, shiny, and bears alternating dark and pale brown cross stripes (Fig. 33), They have incomplete metamorphosis; however, the adult does not have wings.

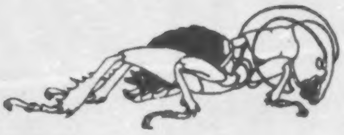


Figure 33 – Jerusalem Cricket

This cricket is not considered an important agricultural pest. They typically feed on roots, tubers and dead animal matter. Populations of this insect are usually small. Occasionally they are found singly or in small numbers in the yard after soil has been dug. Because of their large size and frightening appearance they may be of some concern to the home owner. Infrequently they may enter the home.

In the spring, the female deposits eggs in a small mass in the soil. Development usually requires about one year. In the summer, adults can be found below soil level, under stones, logs, garbage pails and other large objects. These insects typically forage for food at night.

Control

Because of the small number of these insects that are found around the home, it is questionable if any extensive control measures can be justified. Removal of trash piles or other areas where insects breed may give some relief.

BRISTLE TAILS

The silverfish and firebrats or bristle tails are a primitive group of insects. Most are quite similar in appearance, being flattened and carrot-shaped with the head wider than the thorax. All have elongate slender antennae, are wingless and the abdomen terminates in 3 elongate slender appendages (Fig. 34). The body is typically covered with scales and the mouth parts have well developed mandibles.

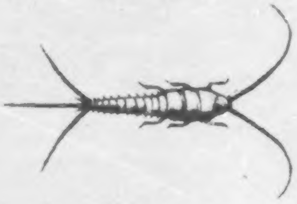


Figure 34 – Bristle Tails

This is a fairly small group of insects with about 20 species occuring in the United States. Of these only a few species are commonly encountered in structures. This group is best developed in the tropics and prefer warmth and high humidities. Correspondingly, the indoor inhabiting species found in the United States are most frequently found in the warmer, more moist areas of the home or industry. The 2 most common household pests in this group are the silverfish, Lepisma saccharina and the firebrat, Thermobia domestica. The adult silverfish is uniformly silver to brown and the firebrat is mottled grayish brown. Both are about 1/2 inch long in the adult stage and develop with incomplete metamorphosis. Their life history is quite similar. Eggs are deposited in cracks and crevices and hatch in about 2 weeks under ideal environmental conditions. Adulthood is reached in 3 to 4 months, but they may continue to molt and not reach full size for a year or more. Environmental conditions seem to dictate the prevalence and location of silverfish in the home. They are more sensitive to moisture and prefer relative humidities from 70 to 100% and temperatures between 70 and 80°F. The firebrat is less sensitive to moisture and is frequently found in very warm situations, such as behind stoves, around hot water heaters, in bakeries and other similar localities.

These pests are primarily a nuisance and typically do not consume large amounts of food. Most damage results from feeding on fabrics and paper materials. As a rule, books and papers that are in constant use are little damaged. Other materials attacked includes rolled oats, ground beef, sugar and dead insects. They seem to prefer materials that are either high in carbohydrates or protein. Feeding damage is typically irregular, damaged surfaces stained yellow and littered with scales.

Control

Since most of these insects can live up to a year or more without food, sanitation is of little value in attempting to eliminate an infestation of bristle tails. These insects can also feed on a variety of very common and necessary materials found in the home; hence, it would be extremely difficult to eliminate all possible foods.

Chemical control is best achieved with residual chemicals. In most cases treatments restricted to the indoors will give thorough control. The sprays should be thoroughly applied to floor and wall moldings, behind drawers, under furniture, cracks and crevices, drapes and the floor and ceiling of attics. It may be necessary to repeat treatment after a 2-month period.

SOLPUGIDS

These arthropods are also commonly known as sun spiders, vinogerones, and wind scorpions. The solpugids are spider-like in appearance but have no waist-like areas; that is, the thorax and abdomen are broadly joined (Fig. 35). Unlike spiders these arthropods have a pair of well developed tactile appendages (palps) that appear very leg-like. Common species may reach 2 inches in length The large size plus a very well developed pair of jaws (Chelicerae) give them a fearsome appearance.

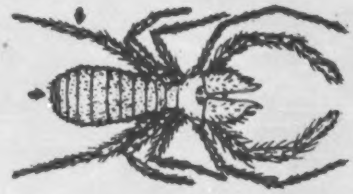


Figure 35 – Solpugid

There are approximately 75 species of solpugids in the United States, most of which are found in the desert areas of the southwestern states from Texas to California. The chelicerae of solpugids are strong, awesome looking and can break human skin. However, these creatures have little or no venom and are relatively harmless to man.

Although sun spiders are relatively common in desert areas, little is known about their biology. They are nocturnal in habit and are predaceous on other arthropods. They frequently may be seen around lights at night feeding on attracted insects.

Control

Many consider these arthropods as beneficial, since they attack and consume large numbers of pest insects. However, because of their grotesque appearance, they may be of considerable concern if they should wander into a home. In most areas these animals are not common enough to justify control.

CLOVER MITE

The clover mite (Bryobia praetiosa), although about the size of a pin head, is one of the larger mite species. The color of this species may vary from brown to pale orange, but when seen in the home they are typically blood red. This species is characterized by its two front legs extending forward as long or longer than its body. Like other mites, this species has 8 legs (Fig. 36).

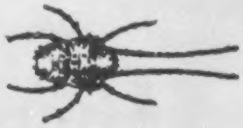


Figure 36 – Clover Mite

The clover mite problem exists over much of the country. In only a few of the southeastern states do home owners seem to be free of invasion by these pests. Outdoors this species feeds on a variety of herbaceous plants, grasses, alfalfa and clover. The clover mite most frequently becomes an annoying household pest in housing developments where new lawns have been established and where there is a heavy growth of well fertilized grass next to the foundation. The feeding activity of these mites seldom causes extensive damage. The problem arises when the host plant upon which it is feeding dries up or is removed. At this time, the mite seeks a new host and in doing so will enter the home through window orifices, door sills and any other available openings. This pest enters the home in massive numbers in the fall and early winter months. The mites at this time are apparently searching for hibernating sites in response to prevailing cooler temperatures and a decrease in the succulence of the host plant. The adults are capable of overwintering within the home. A second migratory period may occur in the spring. This is apparently a movement from hibernating sites to a food source.

The clover mite does not bite man and normally does not feed on plants in the home. The problem arises from their mere presence. A heavy migration may result in several hundred thousand of the mites entering the home. These mites get into clothing, beds and food. It is nearly impossible to remove them and if crushed they stain surfaces red.

Like other mites and ticks, this species passes through 4 stages in its life cycle: egg, larva, nymph and adult. The female lays bright red eggs in foundation cracks, under bark and other protected locations. The newly hatched larvae move to grasses, clovers and other plants to feed. After a short feeding period, the larvae return to protected areas to molt. They feed and molt 3 times before becoming adults. They suck juices from their host plants but do little damage. They are active during the spring and fall months with activity decreasing during hot summers and cold winters. There are from 3 to 5 generations per year.

Control

In areas where clover mites are a recurring problem it is advisable to set up a program to prevent them from entering the home. Once inside they can be killed with certain sprays, but they are more likely to show up again. Prevention can be obtained through chemical and cultural practices.

Home invasion is more likely to occur when grass and shrubbery is growing against foundation walls. Since it is difficult for these mites to crawl across rough surfaces, a barrier of pea gravel or bare soil of 18 to 24 inches wide along foundation walls will stop many of them. A chemical barrier may also be sprayed adjacent to the foundation. If possible, the inside of the foundation wall should be treated. Most of the miticides with longer residual activities are effective.

SNAILS AND SLUGS

Snails and slugs are increasing in importance as household pests in the United States. They are most important as garden pests feeding on young seedlings and the more succulent parts of many species of ornamental and garden plants. However, occasionally they may assemble in large numbers in basements, on walls and entrance ways and along walks, making these areas unsightly. They leave a trail of mucous wherever they crawl and the trails dry to silvery marks which may be objectionable.

Thirty-two species of slugs occur in the United States. Of these only a few are of importance to the home owner. These are the spotted garden slug, Limax maximus; the tawny garden slug, Limas flavus; and the gray garden slug, Derocerus agrestes. These species are very similar in appearance, but vary considerably in coloration and size. The spotted garden slug may reach a length of 8 inches whereas the gray garden slug rarely exceeds 1 inch in length. The tawny garden slug reaches a maximum length of 4 inches.

Of the several hundred species of snails that occur in the United States, only a few are of any importance to the home owner. The brown garden snail, Helix aspersa is the most important snail pest in the United States (Fig. 37).

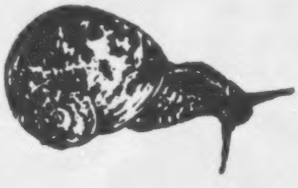


Figure 37 – Brown Garden Snail

Snails and slugs pass the winter in sheltered situations out-of-doors in colder regions, but continue activity throughout the year in greenhouses or in warmer regions. Snails appear to be more cold hardy than slugs. Both snails and slugs are hermaphroditic, that is, both male and female sex organs occur within each individual. Common slugs deposit their eggs in masses of 25 or more beneath rocks, boards, leaf litter and other moist areas. Oviposition occurs from spring to fall. Common snail species deposit from 10 to 200 eggs in shallow one-inch cavities prepared by the parent snail. The average incubation period of common snails and slug eggs vary from 10 to 20 days. Soon after emergence from the eggs, the young snails and slugs begin to move about in search of food. They remain for 4 to 5 weeks in a colony near the place where the eggs are deposited. From 1 to 3 years may be required for them to attain full size.

Control

Snail and slug control, as with other dooryard pests is usually best achieved through a combination of sanitation and chemical control. Sanitation, which is aimed at reducing breeding and hiding places, can be achieved by removing trash, compost, lumber piles, decaying logs and trimming overgrown shrubbery and ivy.

Baits are an effective means of control. The soil should be dampened prior to scattering the bait on the ground and on the plants immediately around the house. Best control is obtained on moist or foggy nights or in other damp situations when these pests are most active. The premises should be treated twice a week until the problem subsides. The property owner or operator should dispose of the dead snails to prevent the buildup of flesh flies.

DOMESTIC RODENTS

Domestic rodents have co-existed with man in his habitats for centuries. They have eaten man's food and wastes and have shared his living quarters. They have become man's chief vertegrate pest because of their great reproductive capacity and their ability to adapt to new environments. Aside from consuming man's food, the domestic rodents are involved in contamination of foods by defecation, destruction of building structures by their gnawing habits, and transmission of diseases and parasites of medical and veterinary importance. Some of the diseases that rodents are directly or indirectly involved in imparting to man are plague, murine typhus, infestious jaundice, rate-bite fever, food poisoning, poliomyelitis, and rabies. A few examples of the parasites conveyed to man and animals are nematodes, spiny-headed worms, flukes, tapeworms, fleas, and ticks. Control measures are essential and costs of control are low as compared with losses brought about by rodents even without consideration of diseases. Rats alone generally outnumber the human population by 3 to 2. The average cost in goods damaged and food eaten by a given rat is estimated at 1/2¢ each day. This comes to over $1.80 for each rat in a year, or a total of over $250,000 for a city of 100,000 human population.

Identification

The 3 main domestic rodents found in the United States are the Norway rat (Rattus norvegicus), the roof rat (Rattus rattus), and the house mouse (Mus musculus). The Norway rat is distinguished from the roof rat by several factors. The Norway rat has coarser hair, close-set ears, and its muzzle is blunt. Its tail color is dark dorsally and light ventrally. The tail is also usually shorter than the combined length of the head and body. The fur coloring changes from grayish-brown on the back to grayish-white on the belly. Adults weigh between 12 and 20 ounces and are 7-1/2 to 10 inches in head and body length. The tail length is between 6 and 8-1/2 inches. The feces are capsule-shaped and about 3/4 inch long (Fig. 38).

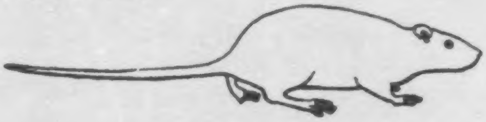


Figure 38 – Norway Rat

The roof rat is smaller than the Norway rat. This rat has large, membranous ears and a sharply-pointed muzzle. The unicolored tail is usually longer than the head and body. The adult head and body length is between 6 and 8-1/2 inches while the tail ranges between 7 and 10 inches. The adult weight is from 8 to 10 ounces. The feces differ from those of the Norway rat in that they are about 1/2 inch long and are spindle-shaped. The roof rat has 2 color phases. The black rat phase has a sooty black back and a gray belly. The Alexandrine rate phase is grayish-brown on the back and ranges from gray-white to yellow-white on the belly (Fig. 39).

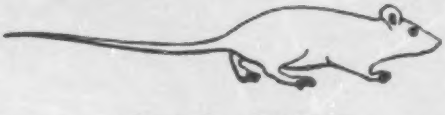


Figure 39 – Roof Rat

The house mouse resembles the roof rat in that they both have large ears, pointed muzzles, and slender bodies. However, the house mouse is a great deal smaller. The tail is unicolored, has little hair, and is about as long as the head and body. The adult mouse can be distinguished from a young roof rat by virtue of the head and feet of the mouse being distinctly smaller in proportion to its body size. Adults weigh 1/2 to 3/4 ounces and are 2-1/2 to 3-1/2 inches long in head and body length. The tail measures between 3 and 4 inches long. The feces are 1/8 to 1/4 inch long and are rod-shaped (Fig. 40).

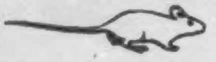


Figure 40 – House Mouse

Biology

The specific biologies and behaviors of these rodent pests are presented in Table 11. Rodents build nest wherever security, food, and water are available. Preferred nest sites include enclosed spaces between walls and floors, under counters, machinery, or shelving, in trash piles, or in burrows in the ground. Nests are well hidden and are rarely discovered during routine inspection.

Control

There are 2 basic methods of domestic rodent control. The first method is environmental management; that is, maintaining or changing the environment such that it no longer is conducive to rodent infestation. When environmental management is achieved, it is a much more permanent form of control than is the second method: rodent extermination. Rodent extermination is the elimination of the existing population of pests. The second method of control employed alone, without preventative measures, merely invites new infestations.

Environmental Management

Environmental management uses sanitation and exclusion as keys to rodent control. Sanitation practices entail the removal of any excess material on which rodents may feed or drink. Garbage or waste areas are especially vulnerable to attack by domestic rodents. Containers should be equipped with rodent-proof, tight-fitting lids. Placing garbage cans and other containers of stored foods on elevated racks having a 6-inch clearance above the floor helps keep storage areas cleaner and easier to inspect (Fig. 41). Other materials which may draw rodents are excessively available water, rotting or overly ripe fruit which has fallen from trees, or any other refuse containing food substances.

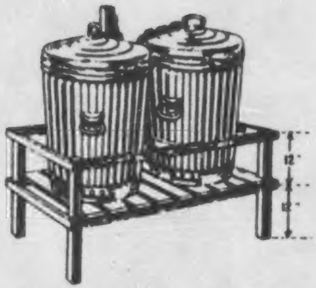


Figure 41 – Elevated Rack

The exclusion method of rodent control involves the eradication of all possible nesting sites and avenues of entrance into buildings (Fig. 42). Exclusion practices are frequently difficult because of the habits and behaviors of rodents. Rats and mice are quite agile and capable of entering through extremely small openings. In general, buildings with openings larger than 1/2 or 1/4 inch are not rat- or mouse-proof, respectively.

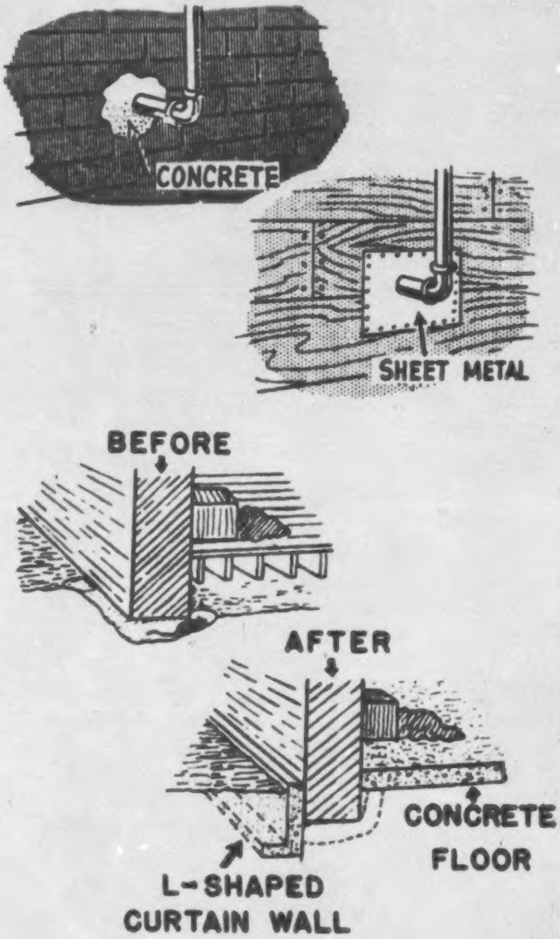


Figure 42 – Methods of Preventing Rats from Entering a Structure

Rodents have great climbing abilities, also. They are capable of gaining entry to a building by climbing vertical pipes up to 4 inches in diameters, climbing shrubs, trees, or vines adjacent to structures, and crossing wires to upper stories. Climbing abilities are best developed in roof rats and house mice. Rodents have evolved other adaptive skills and behaviors. They can jump 3 feet vertically and 4 feet horizontally. They can enter a building through drains and toilets. They are able to fall 50 feet without being killed and can burrow 4 feet down into the soil. They are capable of gnawing through wood, fiberboard, and many plastics. Exclusion is therefore difficult, but can be achieved through the modification of existing buildings or in the design of buildings to be constructed. In existing buildings, enclosed spaces, such as those between double floors, under cabinets, and under stairways, should be removed or modified. Stored materials or containers should be placed on shelves or racks. Outdoor potential nesting sites, such as rubbish piles or junk piles should be removed. Entrances to buildings, such as door jams, borders of windows, house vents, and furnaces, should be inspected.

Extermination

Rodent extermination as a control method is to be considered only as a supplement to environmental management. This method merely eliminates the existing population of rodents temporarily. Extermination can be accomplished by trapping, poisoning, and fumigating. Trapping is the preferred method of control when rodenticides are prohibited or where poisoned rodents might die in inaccessible areas and cause foul odors. Snap traps are generally more effective than cage traps. They should be equipped with a large and sensitive trigger which may or may not be baited. Effective baits include meats (especially bacon), various grains, dried fruits, peanut butter, and pastries. Baits should be fresh daily. Mice are more easily trapped than rats because they tend to be less fearful of traps. Traps for mice should be spaced every 3 or 4 feet adjacent to baseboards, boxes, platforms, wall junctions, and on rafters. Rat traps should be placed along established runways (Fig. 43). Rat runways can be determined by using tracking powder or looking for rat signs. All traps should be anchored well and checked daily. The reason traps are placed next to vertical objects is that rodents are highly touch sensitive in their whiskers. They appear to use this sense to guide them along vertical objects on the floor.

Rats typically avoid new or unfamiliar objects along their paths. This aversion is not a problem with mice, but it does hinder the effectiveness of traps and poison baits in rat control. It is often necessary to allow a familiarization period before traps or toxic baits can produce good results. Often a good place for rat traps is in surprise locations along their runways just behind an object which has been in the path for some time.

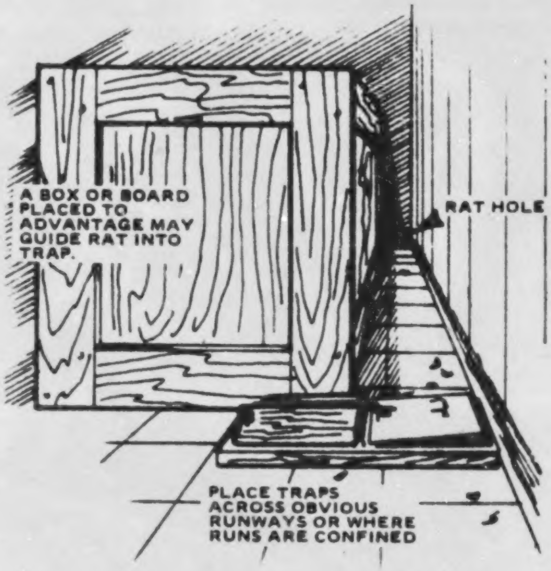

A BOX OR BOARD PLACED TO ADVANTAGE MAY GUIDE RAT INTO TRAP.
RAT HOLE
PLACE TRAPS ACROSS OBVIOUS RUNWAYS OR WHERE RUNS ARE CONFINED

Figure 43 – Placement of Traps in Established Runways

The use of poison baits is the most effective means of extermination. When using poison baits, first use an untreated bait until the rodents will freely accept it. This will also reveal which baits are more desirable. When the baits are being consumed regularly, begin treatment of the bait with a registered rodenticide. This procedure is known as pre-baiting. Untreated baits should be used from 2 to 4 nights prior to actual rodenticide treatment. Other factors which determine the success of poison baits include the choice of the proper food for bait, the correct distribution of baits over the entire home range, the proper mixture of poison in the bait, and the use of the correct rodenticide. Good baits are cereal grains, fish, meats, fruits, and vegetables.

Rodenticides are of two types: chronic poisons (anticoagulants) and acute poisons (stomach poisons). Anticoagulants are decidedly the safest for general use. However, rodents must feed on the bait for several days for the poison to be effective. Bait stations in the form of a tunnel or box placed adjacent to a vertical surface usually increases the effectiveness of anticoagulant baits (Fig. 44). Stomach poisons are sometimes laid down as a tracking powder and are ingested by the rodents when they groom themselves.

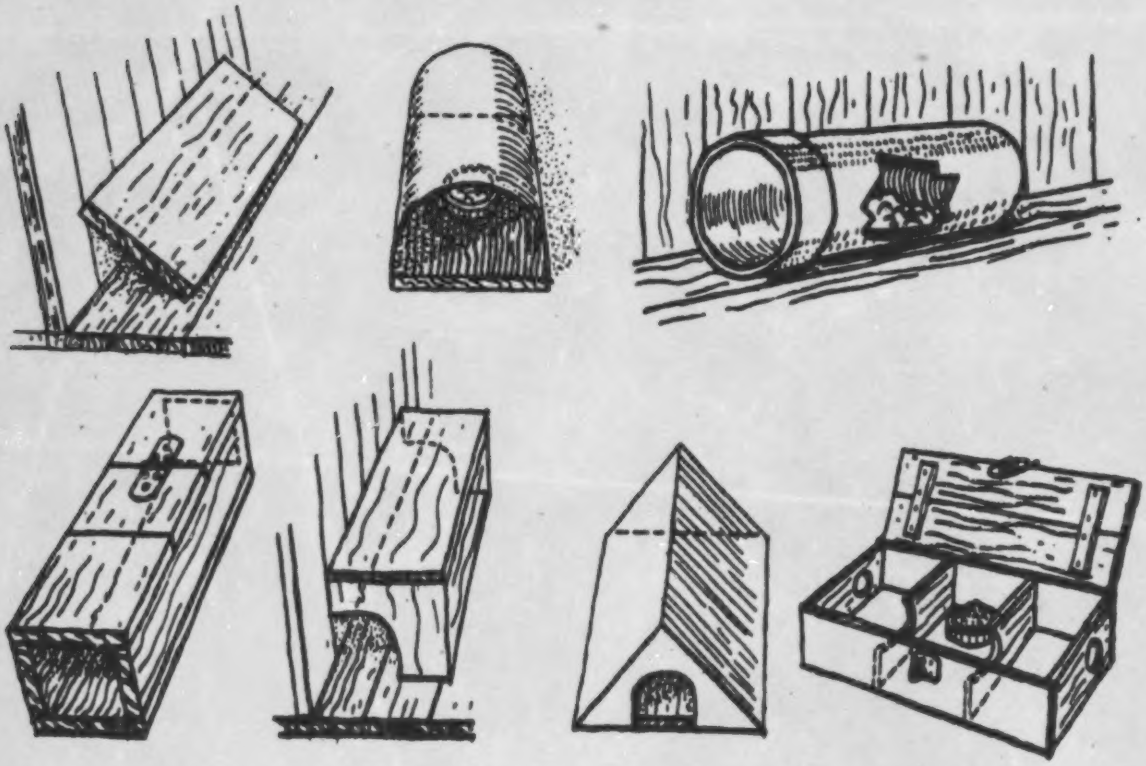


Figure 44 – Types of Anticoagulant Bait Stations

Fumigation for domestic rodents is not widely used around the home but is commonly used on ships. Since the nesting sites of rats and mice are frequently in well-protected areas, fumigants will often be ineffective. Rodent fumigation requires great skill since it can be dangerous to the person handling the poisons.

Table 11. Specific Biology of Domestic Rodents

Rodent	Life Cycle	Home Range*	Food
Norway rat Rattus norvegicus	8 to 9 young per litter. Two to 4 litters. Nine to 12 months life expectancy.	100 to 200 feet diameter.	Omnivorous; prefer garbage, meat, fish, grains. One-half 1 ounce water per day.
Roof rat Rattus rattus	5 to 7 young per litter. Two to 4 litters. Up to 1 year life expectancy.	100 to 200 feet diameter.	Omnivorous; prefer vegetables, fruits, nuts, grains. 1 ounce water per day.
House mouse Mus musculus	5 to 6 young per litter. Up to 6 litters. Up to 1 year life expectancy.	Very small; usually within or around 1 building.	Omnivorous; cereal grains preferred.

*Refers to normal distances these rodents will travel from their nesting sites in search of food, water, or other requirements.

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LEARNING AT HOME
Review Questions – Section 2

1. To what order do ants belong __________.
2. Name 3 social insects __________.
3. There are usually __________ forms or castes of ants found within a colony.
4. The ant queen mates __________ times.
5. The food of carpenter ants is __________.
6. Harvester ants are __________ eaters.
7. The shape of a cockroach's body is ______.
8. There are over __________ species of cockroaches found throughout the world.
9. The egg case of a cockroach is called ______.
10. The female German cockroach carries the egg capsule until __________ the eggs hatch.
11. Which cockroach is likely to be found in any room in the house __________.
12. Scorpions have __________ legs.
13. Scorpions have __________ vision.
14. The bed bug requires __________ to develop from egg to adult.
15. The black widow spider web runs in ______ directions.
16. The female black widow spider may live __________.
17. The female tarantula may live __________.
18. Hard ticks pass through __________ stages.
19. Flea larvae feed on __________.
20. Clothes moths and carpet beetles develop with __________ metamorphosis.
21. The first step in the control of stored food pests is to __________.
22. The adult sawtoothed grain beetle is approximately __________ long.
23. Dead snails are frequently a source of ____.
24. Name 3 types of food of the field cricket __________.
25. Silverfish are a __________ group of insects.

OUTSIDE ASSIGNMENTS

1. Make up some Tables similar to the one below, covering the characteristics of interest to you. Try and see how many insects and related pests you can gather information on.
2. Keep these neat and make them as complete as possible so they will be of value to you when placed in your note book.

Common Name	Fleas	Wasps	Yellow jackets
Latin Name	(cat flea) Ctenocephalides felis	(genus) Polistes	Vespula pensylvanica
Color	Brown to brownish black	Yellowish tan to brown	Black and yellow. Yellowish bands.
Size	Female-.08" Male slightly less	0.45"-0.6"	.5-.7" long
Food	Adult fleas must have blood to produce eggs. Larva feed on organic debris.	Other insects	Other insects and liquids high in sugar. Diet is quite varied.
Nesting Habits	Nest in sleeping place of host or on host. Found in cracks and crevices, rugs and upholstered furniture.	Paper like nests consists of circular combs of cells. Suspended.	Usually nest in ground.
Misc. General Characteristics	Eggs heatch in 2 weeks. Larva full grown in 2 weeks. Pupate-1 to 2 wks. Body compressed laterally to allow rapid movement through hair.	Generally more peaceful than yellow jackets. Several hundred worker wasps in a colony.	The name is applied loosely to all black and yellow hornets.
Pest or Not and Why	Readily bite people. Scratching bitten areas sets up secondary infection. Can transmit disease.	Generally are beneficial, but capable of sting.	Severe sting

WOOD DESTROYING ORGANISMS – COMMON FEATURES OF SPECIFIC PESTS, RECOGNITION, AND CHARACTERISTICS OF PEST PROBLEMS

Kenneth R. Hobbs, Ph.D.
Bioecologist
Interdisciplinary Systems, Incorporated

INTRODUCTION

The most damaging animals that attack structures are the termites. The beetles are the next most important group of insect which attack wood. On the basis of distinctive habits and problem-solving challenges, the beetles rank near the top. There are 2 kinds, those that will reinfest the wood they are found in until the wood can no longer be used and must be replaced, and those that emerge from wood after it has been milled (and installed for whatever use it was intended), but for one reason or another cannot attack the same piece of wood again. Third in importance, depending upon geographieal location, are the bees, wasps, and ants.

Economic losses from pileworms and certain crustaceans occur in many areas where wood, concrete, and other materials come in contact with sea water. Fungi are also an important source of damage to wooden structures in areas where the climate is normally quite warm and humid. Wood rotting fungal spores are found everywhere and are instantly prepared to germinate the second suitable environmental conditions prevail.

The relative importance of a given structural pest may vary from geographical area to area. The following is what California has experienced over a period of time. Taking statistics from quarterly reports in the mid-1960's issued by the Structural Pest Control Board, California Department of Professional and Vocational Standards, there are some distinct trends which are similar to those of many other geographical areas. There was an average of 82,000 reports submitted by licensed pest control operators to the Board for 7, three-month periods. Subterranean termites were found in 43% of the inspections, drywoods in 33%, wood rot in 21%, beetles in 2%, and dampwood termites in less than 1%. In 41% of the inspections, faulty grade level was present; in 33%, earth-wood contact was discovered; and in 26%, no infestations and no apparent conditions which could lead to an infestation were found.

LISTS AND KEYS OF PESTS ATTACKING WOOD PRODUCTS

The list presented below is a representation of the most economically important structural pests occurring in the Western United States and Hawaii. The animal list is prepared phylogenetically (i.e., with the most advanced and complex organisms presented last and with the most closely related adjacent to each other).

Mollusca (oysters, clams, mussels, etc.)
  Pholadidae (Family)
    Rock Oyster – Pholadidea penita (Conrad)
  Teredinidae (Family)
    Giant pileworms – Bankia sectacia (Tyron)
    Pileworms (Teredo navalis L., T. diegensis (Bartsch).

Crustacea
  Isopoda (Sub-order)
    An isopod – Limnoria lignorum (Rothke)
    Pill bug borer – Sphaeroma pentodon (Richardson)

Isoptera
  Hodotermitidae (Family)
    Dampwood termite – Zootermopsis angusticollia (Hagen)
    Nevada dampwood termite – Z. nevadensis (Hagen)
  Kalotermitidae (Family)
    Drywood termite – Incisitermes minor (Hagen)
    Desert drywood termite – Marginitermes hubbardi (Banks)
  Rhinotermitidae (Family)
    Western subterranean termite – Reticulitermes hesperus (Banks)
    Eastern subterranean termite – R. flavipes (Kollar)
    Black-legged termite – R. tibialis (Banks)

Coleoptera
  Anobiidae (Family)
    Western deathwatch beetle – Trypopitys punctatus (Lec.)
    Softwood powder-post – Hadrobregmus gibbicollis (Lec.)
    Furniture beetle – Anobium punctatum (De Geer)
    Deathwatch beetle – Xestobium rufovillosum (De Geer)
  Bostrichidae (Family
    Lead cable borer – Scobicia declivis (Lec.)
    Black polycaon – Polycaon stouti (Lec.)
  Lyctidae (Family)
    Oldworld lyctus beetle – Lyctus brunneus (Stephens)

European lyctus beetle – L. linearis (Goez)
Southern lyctus beetle – L. planicollis (Lec.)
Western lyctus beetle – L. cavicollis (Lec.)

Hymenoptera
Formicidae (Family)
Giant carpenter ant – Camponotus levigatus (Smith)
A carpenter ant – C. herculeanus, var. modoc L.
Masculate carpenter and subspecies – C. masulatus (Mayr.)
Amber carpenter ant – C. maccooki (Forel)
Xylocopidae (Family Apidae by some authors)
California carpenter bee – Xylocopa californica (Cres.)
Mountain carpenter bee – X. tabaniformis (Smith)
Valley carpenter bee – X. brasilianorum (Patton)

TERMITES

Termites are relatively primitive insects being most closely related to the cockroaches. They belong to the order Isoptera. This word means equal wings and refers to the fact that the front and hind wings of alates are of equal size and shape (Iso = equal, ptera = wings).

Entomologists have described about 2,200 species of termites for the entire world. However, when compared to the nearly 300,000 species of beetles described for the world, Isoptera is a small, but still important order. Of the species that have been described, only 70 species infest buildings and require control (Ebeling, 1968). There are 13 species of termites in the contiguous United States that require man's attention to a greater or lesser extent. The 2 most serious species of termites in Hawaii are the Formosan subterranean termite, Coptotermes formosanus and the West Indian termite, C. brevis.

Termites occur in virtually every state of the United States and parts of Canada. Alaska is the only state to completely escape thus far. They cause varying degrees of trouble, depending upon the geographical location. The presence of abundance of termites in an area is controlled by their environmental requirements such as temperature, humidity, atmosphere, soil moisture, and soil type. The maps (Fig. 45, 46) illustrate the known distribution of 4 important species of termites in the contiguous United States.

CASTE SYSTEM

Termites have 3 basic castes; reproductive, workers, and soldiers. There are several kinds of reproductives, 2 kinds of workers, and 2 types of soldiers. In some species, certain castes are missing, in others, all castes are present. The individuals in each caste can be either male or female, but only the reproductives will serve to maintain the colony population. The primary reproductives (or alate, because of the presence of wings), a king and a queen, will remain together throughout their lives. It is necessary for the king and queen to periodically mate to maintain the desired frequency of fertilized eggs. There are secondary (supplementary) reproductives that begin to appear in the colony once it has been established by the primary pair to aid in egg laying. Finally, in some species, there is a third type called tertiary reproductives. These also function to aid in maintaining colony strength.

Most of the work in the colony is done by the worker caste (if one is present) which are sterile adults. Whether there is a worker caste or not, nymphs (future reproductives mostly) help with the tasks of the colony. At one time, soldiers were very effective in warding off the natural enemies of the colony. Today, the heads and mandibles of the soldiers (some species) are large and cumbersome and difficult to swing into action. Soldiers are also sterile adults. In some species there is a second type of soldier, called the nasutus. These individuals wage a chemical warfare against intruders by squirting a sticky fluid from a tube located on the front of the head.

SWARMING AND MATING

Most social insects swarm. This is one means by which certain social invertebrates perpetuate the species. A well-established colony of termites may develop hundreds to thousands of winged kings and queens (primary reproductives), depending on the species. This usually occurs during the time of year best suited to the needs of the termite. For example, if subs (an industry abbreviation for subterranean termites) were to swarm during the month of August in the desert, they would soon perish. Subs prefer warmth and there must be enough water present so that they won't dry out. Therefore, on the first warm day following the first fall rains, subs emerge from their swarm tubes in great numbers.

The act of swarming is dangerous. Winged termites tend to be clumsy fliers and are easy prey for hungry birds and predaceous insects. On an average less than 3% of the swarming termites

Continued on Page 65

A KEY TO THE IDENTIFICATION OF DAMAGE CAUSED BY WOOD DESTROYING ORGANISMS

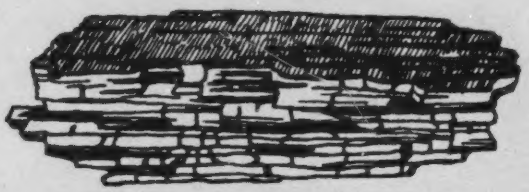
A biological key is a tool prepared by a specialist for students for determining names of specific or groups of organisms. The key should be prepared with terms understood by those likely to use it. Most of the members of the pest control industry are specialists in their own right, therefore, the use of such terms as frass, pellet and tunnel are not unfamiliar and will be used in the following key.

Suppose someone has just handed you a piece of wood with some damage in it. There are no live specimens, but a functional key could help you determine the organisms which caused the damage.

1. No apparent galleries, chambers, tunnels, or excavations in the wood visible, and wood is or obviously has been wet (or moist) for months or more 2

1'. Either galleries, chambers, tunnels, small holes, or excavations readily visible from the surface or within the wood 3

2. Checks at right angles and parallel to the grain of the wood . . . Brown Cubical Rot

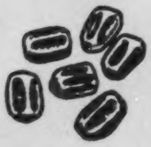


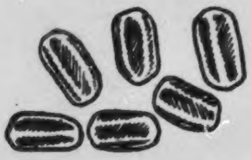
2'. Checks when present found running only parallel to grain of wood . . . . Other Wood Rots

3. Excavations containing pellets of distinct shape and/or size 4

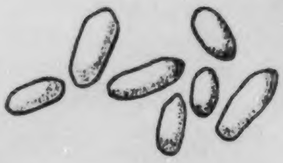
3'. Excavations containing no pellets of any kind 9

4. Pellets of distinct shape and size with longitudinal riflings 5

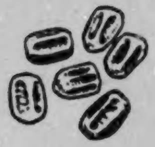




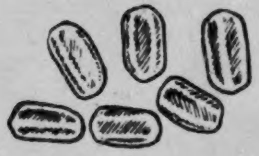
4'. Pellets varying in either size or shape and without riflings 6



5. Pellets no longer than the diameter of a paper clip wire, damaged wood apparently dry . . . . . . .Western Drywood Termite



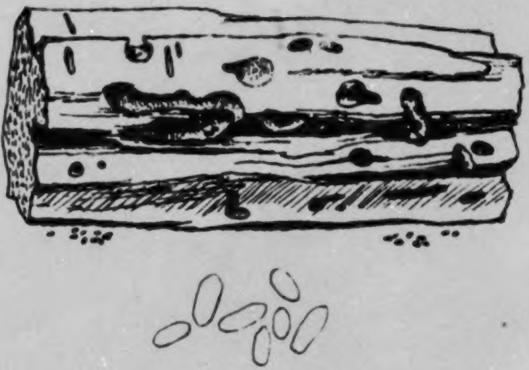
5'. Pellets nearly as long as twice the diameter of a paper clip wire, damaged wood apparently is or has been damp . . . . Dampwood Termite



6. Cross-sectional view of tunneling distinctly round, pellets obviously varying in size and tapering at both ends 7

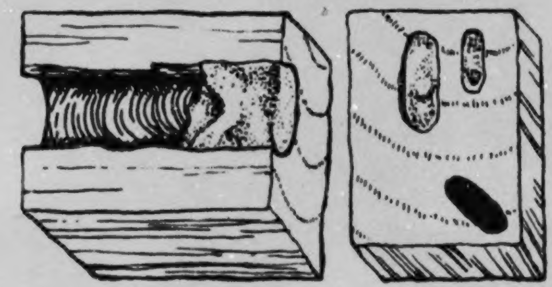
6'. Cross-sectional view of tunneling distinctly oval, pellets of similar size in groups or with masses of linear, fiberous shavings of wood 8

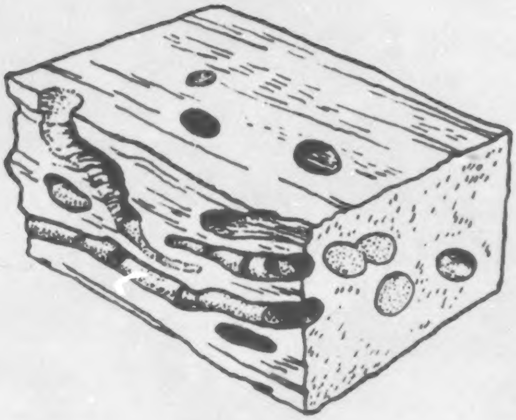
7. Tunnel indistinct due to the common presence of moisture and wood rotting fungi, an occasional distinctly shaped pellet most of which has been disintegrated to a fine powder . . . Softwood Powderpost Beetle (Anobiidae)



7'. Tunnels very distinct running either with or against the wood grain, tunnels clean except for ccollections of distinctly shaped and sized pellets . . . . . Deathwatch Beetles (Anobiidae)

8. Cross-sectional view of tunnel extremely fat. 4 or more times as wide as high . . . . Flat-headed Borers (Buprestidae)



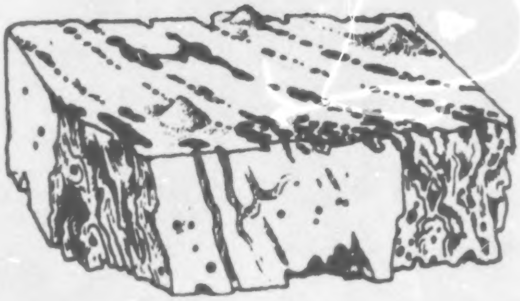


8' Cross-sectional view of tunnel no more than twice as wide as high . . . . Round-headed Borers (Cerambycidae)

9 Excavations or galleries obviously containing fraas 10

9'. Excavation or galleries not containing frass; if frass is present, soil is also present . . 14

10. Individual particles of frass seen with the unaided eye or tunnels partially to well-compated with frass 11

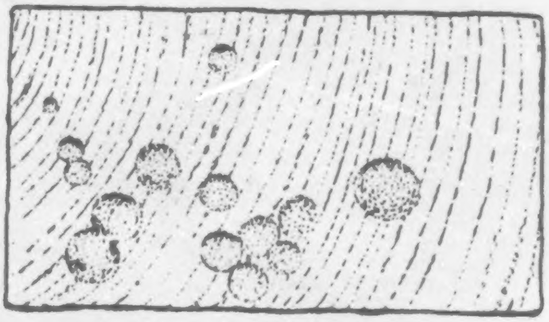


10'. Individual particles of frass as fine as chalk dust, individual tunnels less than 2 millimeters in diameter . . . . True Powderpsot Beetles (Lyctidae)

11. Damage found only on the surface of the wood just under the bark 13

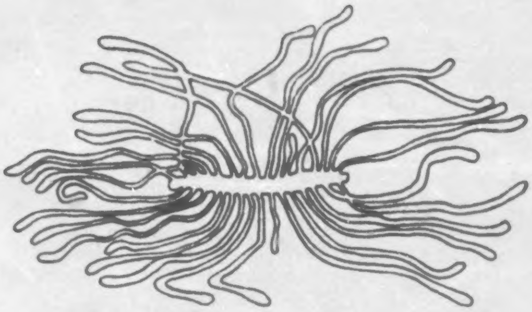
11'. Damage found within the wood 12

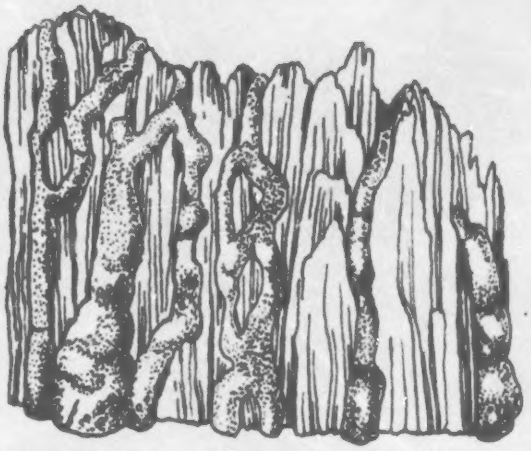
12. Tunnels uniform in size, less than 3 millimeters in diameter, damage normally found only in hardwoods . . . Lead Cable Borer (Bostrichidae)



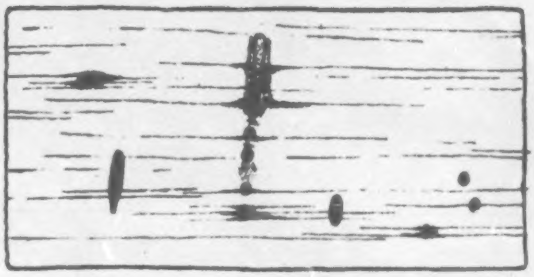
12'. Tunnels varying in size up to 3/8 of an inch in diameter, packed tightly with coarse frass having a sand paper-like texture . . . . Black Polycaon (Bostrichidae)

13. Tunnels or galleries radiating in all directions from a so-called egg gallery with visible egg nitches, individual tunnels not exceeding 4 millimeters in width . . . . . Bark Beetles





13' Tunnels progressing in a serpentine fashion over the surface of the wood, usually at least 4 times wider than deep . . . . Flat-headed Borers



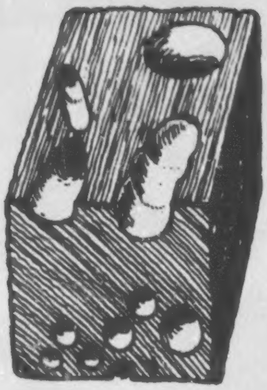
14. Wood sparsely tunneled, diameter of the tunnels not exceeding millimeters in diameter, tunnels stained dark brown to black . . . . Ambrosia Beetles

14' Wood usually heavily tunneled or with large excavations, if sparsely tunneled the diameter of the tunnel is from 1/2 to 3/4 of an inch (13 to 20 millimeters) 15

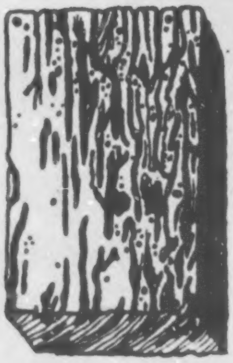
15. Wood found in association with or within brackish or salt water 16

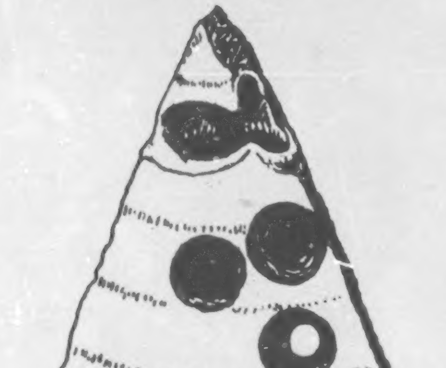
15'. Wood not found in association with or within brackish or salt water 17

16. Tunnels one to many, large (from 3/8 to 1 inch in diameter)(10 to 25 millimeters), tubular, nearly perfectly circular holes as seen in cross-section, tunnels lined with white, smooth shell . . . . . Pileworms (realted to clams, oysters)



16' Tunnels multiple, extremely small, both inside and on the surface of the wood, tunnels never lined with shells . . . . Limnoria (Crustacean)

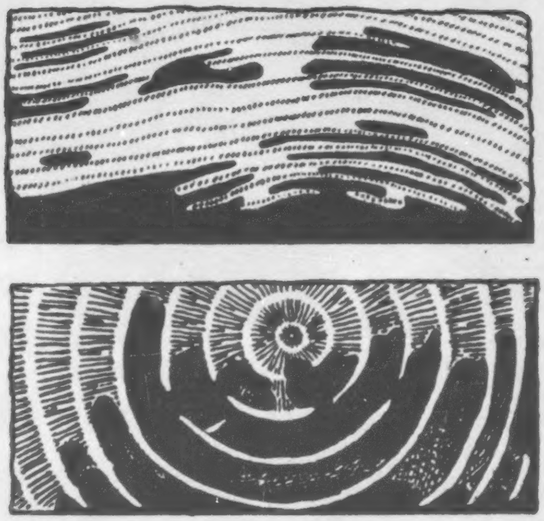




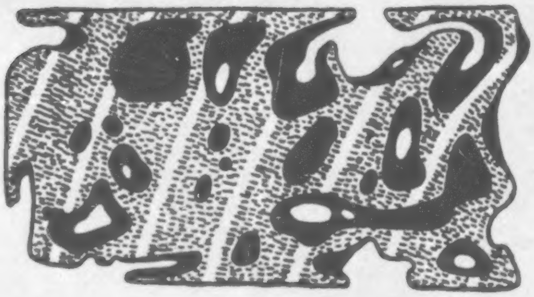
17. Tunnels one to many, nearly perfectly circular in cross-section, extending with the grain of the wood in either direction from an entrance hole, 1/2 to 3/4 (13 to 20 millimeters) of an inch in diameter . . . . (Carpenter Bees)

17'. Tunnels forming excavations of indefinite shape or size 18

18. Excavations containing masses of soil particles, surfaces of galleries frequently speckled by liquid feces, obvious avoidance of hard, summer wood . . . . Subterranean Termites



18'. Excavations immaculate, little indication that the hard, summer wood has been avoided (similar to that of drywood termites and frequently takes over such a gallery . . . . Carpenter Ants



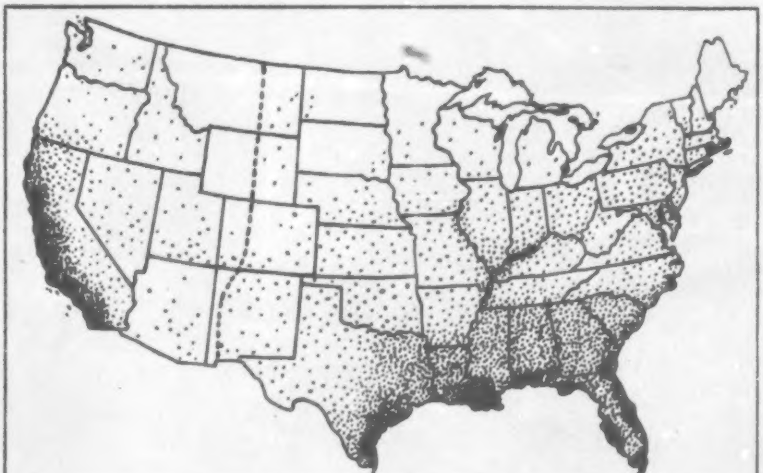


Figure 45 – Relative Occurance of Eastern and Western Subterranean Termites Indicated by Density of Stippling

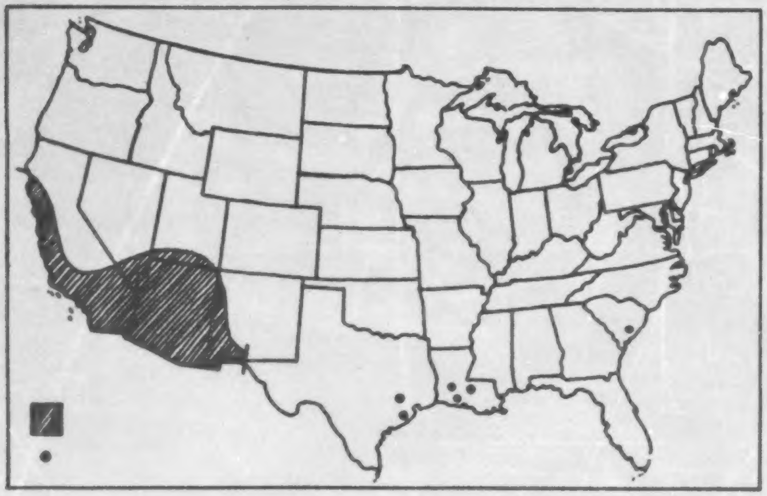


Figure 46 – Distribution of Drywood and Formosan Termites. Shaded Area = Drywood Termite. Dots = Formosan Termite.

survive. The wind has a strong influence upon the direction and distance traveled by the new kings and queens. Once emerged from the nest the primary reproductives eventually strike the ground our of exhaustion or by accident. Tandem pairing commences at once. The queen seeks a suitable location to start another colony. While she is doing this, a king or several kings line up and follow behind her. Frequently, when she turns too abruptly, her followers get lost. Sometimes, males follow males, not knowing the difference. Before mating takes place (or a first chamber is built) termites break off their wings along a basal suture (Weisner, 1965).

Dampwood or subterranean queens usually locate their beginning nests in a place in the soil, frequently near buried wood. Drywoods prefer a crack in almost any kind of wood. Once mating has occurred (hours to one week or more after swarming), the queen produces eggs of the desired caste.

DEVELOPING THE TERMITARIUM

House building begins immediately. The first year very few offsprings are developed in relation to the potential size of the colony. By the end of the second year, many hundreds of individuals will be present. By the end of the third year there may be many thousands. Typically, by the end of the third year, most species will have developed large enough colonies to produce visible winged forms or other obvious signs of their presence.

The royal pair care for the first individuals hatched from the first 10 or 15 (or more) eggs. Once the first brood is well developed, more eggs are laid, and this is continued until all castes are present. Workers or nymphs do the chores of extending the colony, feeding the queen and grooming the eggs, themselves, and younger nymphs.

These primitive insects are cryptic in habit. This means living in seclusion, but not necessarily in darkness. This seclusion provides an air controlled termitarium or "carton" in which the termites have limited control of their environment. Man furnishes the heat energy in structures. In the forest and elsewhere in nature, termites go further into the soil as the atmospheric temperature diminishes. Subterranean termites also go further into the soil as the soil moisture diminishes. Under scuh conditions, drywood and dampwood termites reduce metabolism, develop fewer young, decrease in size, and finally succumb if drying conditions become too severe. For that matter, most termites and other insects fail to attack wood which contains less than 11 to 13% moisture by weight (Chamberlain, 1949).

FOOD, DIGESTION AND GROOMING

Wood is made up of 3 dominant ingredients: cellulose, lignocellulose, and lignin. All plants have varying amounts or proportions of each of these organic substances. The more cellulose in a plant or plant product, the more attractive it is to a termite. Some woods produce toxins or other substances which confer variable susceptibility to termite attack. There are woods from various parts of the world that are quite immune to termite attack (Chamberlain, 1949). However, they are not in abundant supply. Wood products like paper are favorite foods since they are nearly pure wood pulp and cotton fiber. The lignin, a substance avoided by these pests, is removed furing the paper manufacturing process.

Cellulose is digested by a large number of flagellated protozoans that live symbiotically, or mutualistically in the intestinal tract of termites. Many kinds of microorganisms are used by animals to aid in their digestion. Some species of termites also use species of bacteria in digestion.

The termite is very resourceful and eats the caste skins and feces of other individuals. Dead or dying colony members are quickly consumed. It is thought that much of this is caused by the fact that termites groom each other with their mandibles. There are secretions, fungus spores, wood particles, and other attractive substances on body surfaces. Inadvertantly, sometimes a mandible pierces the very thin integument or skin. When this happens, that hapless individual is eaten by those close by. This is one means by which the cellulose digesting protozoa are transferred from the older to younger colony members.

SUBTERRANEAN TERMITES (RHINOTERMITIDAE)

According to Ebeling (1968), subterraneans are by far the most important pests of buildings throughout the world and the principal effort in prevention and control is directed against these insects. From a standpoint of prevention and control, the chief characteristic of subs is that they ordinarily maintain contact with moist soil. They may reach dry wood above ground through "shelter tubes" ("galleries," "runways") which are constructed from particles of earth or sand (or minute bits of wood, coated with a gluey substance from their mouths and gullets). These termites also cover exposed areas of wood upon which they are feeding with a layer of similar material. After returning to their galleries and nests by means of these tubes, the termites can replenish their body moisture by absorbing water through their cuticles. Breaking contact between wood of the infested building and the soil is a principal method of combatting these pest.

In the Rhinotermitidae, 3 species are of considerable importance in the Southwestern United States and Hawaii. These are Reticulitermes hesperus (Fig. 47) in the west, R. flavipes (Fig. 48) in the east (but reported as far west as Texas, New Mexico, and Arizona), and Coptotermes formosanus (Fig. 49), primarily in Hawaii (but also found in several eastern states). In California the principal species of subterranean termite is R. hesperus. Winged reproductives (alates) are dark brown to brownish-black and have brownish gray wings. Including the wings, they are about 3/8-inch in length and the body, not including wings, is about 3/16-inch long. Another species of Reticulitermes, R. tibialis, may be found in some inland areas of California, such as the San Joaquin and Sacramento Valleys and certain high deserts. Weesner (1965) states that the reproductives of R. tibialis may be distinquished by their pale almost whitish wings with brownish veins in the forearea, in contrast to the dark wings of R. hesperus. The most reliable distinction between R. hesperus and R. tibialis is the short, broad, dark-colored head of the soldier of the latter compared with the pale, long, narrow head of the soldier of the former. When the 2 species overlap in distribution, R. hesperus prefers cool, shady, moist places while R. tibialis requires open, sunny, drier locations. The 2 species are equally able to damage wood structures.

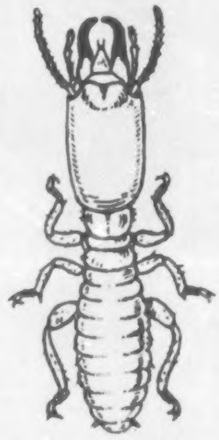


Figure 47 – Dorsal View of the Soldier of the Western Subterranean Termite.

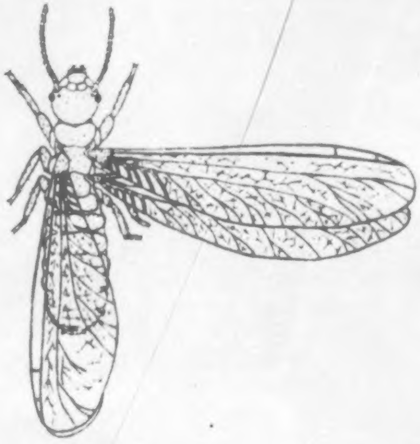


Figure 48 Alate of Reticulitermes flavipes

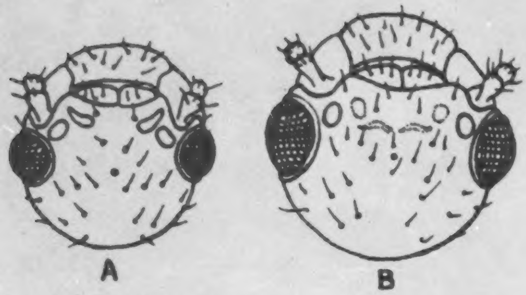


Figure 49 – Head Capsule of Alates of 2 Species of Coptotermes from Honolulu

A. Coptotermes vastator
B. Coptotermes formosanus

After the flight of the winged reproductives of R. hesperus, the colony founding pair (king and queen) may dig some distance to find wood, or may crawl under or into the crevices of a piece of wood on the ground. An irregular cell is constructed in the wood, usually less than 1/8 inch wide and 1 inch long, in which the eggs are laid. There are usually less than 10 eggs in the first clutch, and from 30 to 90 days are required for hatching. The young nymphs obtain food from the mouth or anus of the parents or workers and in a week also feed on the abundant brown fecal plaster in the nest. In the second instar, the nymph contains the intestinal protozoa which enables it to digest cellulose. For the first 2 years most of the termites reach only the fifth instar and are relatively small. Only a colony large enough to supply enough food and a large amount of fraternal feeding will produce the large, well-matured workers and reproductive nymphs of the sixth instar; from 2 to 4 months later the reproductives may attain the seventh instar. Workers not falling victim to cannibalism may live 3 to 5 years, and queens probably live much longer.

Supplementary reproductives are required for rapid increase in numbers of termites in a colony. When groups of workers and nymphs are separated from the mother colony, they form a new colony in 6 to 8 weeks, with supplementary queens developed from some of the short-winged nymphs found in every large colony. A supplementary queen can produce more eggs (60 to 80) in a day at the height of egg-laying than the primary queen does in the first 2 years of the colony's development.

Termites continually groom each other obtaining desired secretions of exudates containing ectohormones. The ectohormones are believed to inhibit the formation of additional members of the sex (or caste) from which they are obtained. This serves as a regulatory mechanism to prevent a disproportionate ratio of males, females, and soldiers in a colony.

Species of Coptotermes species have an even greater capacity for destruction than Reticulitermes. The Formosan termite, C. formosanus, a very destructive species in Hawaii, was recently reported from Houston, Texas, and the known infestations were apparently exterminated. The following year it was again found in Houston, Galveston and in several areas in Louisiana and appeared to have become firmly established in the United States (Fig. 46). On May 6 and again on June 28, 1966, C. formosanus was intercepted in packing material in marine cargo in Lathrop, California. On June 14, 1967, 2 Formosan termites were found in a residence in Charleston, South Carolina. Because all infestations had been in harbor cities, it is almost certain that these termites came aboard ship to the U.S. Many believe that C. formosanus will eventually have the same range of distribution in latitude in the U.S. as it has in other areas of the world.

The most obvious characteristics distinguishing C. formosanus from the native Reticulitermes is its larger size, pale yellow body color, oval shape of the head of the soldier in comparison with the oblong and rectangular head of the Reticulitermes soldier, and the hairy wings (Fig. 50).

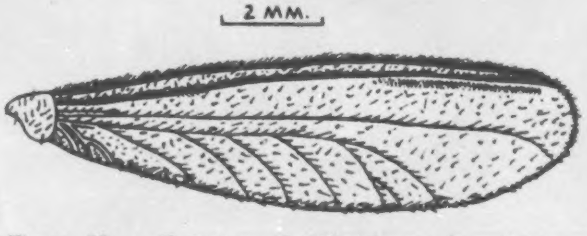


Figure 50 - Forewing of Coptotermes formosanus Showing Numerous Hairs

Formosan termites make nests of a hardened paper-like material called carton in wood in or on the ground, in hollows they have excavated from tree stumps or posts, or in hollow spaces in the walls, floors, or attics of buildings. Runways from nest to wood have been found as deep as 10 feet underground and from 150 to 200 feet long. Beside the primary nest, the older, larger colonies of the Formosan termite frequently build secondary nests close to food sources; these nests contain mainly workers, soldiers, and older nymphs. Like the native subterranean termites of the U.S., the Formosan termite builds earthen shelter tubes over objects it cannot penetrate.

C. formosanus flights usually begin before sun-down and end before midnight. Warm, sultry evenings (especially when following rain) are favorable for extensive flights. These insects are strongly attracted to lights. In contrast to C. *formosanus, other subterranean termites fly during the day,* as might be inferred from their black bodies. In California, R. hesperus generally swarms between 10 AM and 3 PM on the first sunny day following the first rain of the autumn.

Borror and DeLong (1971) indicate that the eastern subterranean termite, R. flavipes is probably the most destructive species in the order, Isoptera. This reference also states that this is the only species of termite inhabiting the northeast. The wing membrane of the forewing of R. flavipes is grayish to a gray-brown. Except for the slightly clouded forearea of the hindwing, it is colorless. Swarming flights take place usually during the spring months of April and May.

DRYWOOD AND DAMPWOOD TERMITES – (KALOTERMITIDIS)

These destructive pests are placed in the family Kalotermitidae which includes about 16 species in the United States. There are 2 genera in this family of concern to the pest control operator. One of these is the western drywood termite. Incisitermes minor and the other is the Pacific dampwood termite, Zootermopsis angusticollis.

This family has no worker caste; therefore, the nymphs, as they continue to molt to adulthood, do the tasks of the workers. Ground contact is not necessary for the drywood. Infestations may be found in structural timber and woodwork in buildings including furniture, telephone poles, wooden derricks, bridges, various dimensions of lumber found neatly stacked in lumber yards, paper, cloth, woodpulp or fiber insulation boards and in other products containing cellulose. Kalis, as they are called in the industry, may also injure living trees and other woody plants.

The western drywood termite tends to cut across wood grain, destroying both the soft spring wood and the harder summer growth (Fig. 18' of key). Subs strongly follow the grain of the wood, foraging only the soft spring wood (Fig. 18 of key). Contrary to subs (which develop liquid feces), the drywood termite develop pellets of specific size and markings (Fig. 5 of key). These pellets are eliminated from the galleries through "kick holes." Pellets tend to accumulate on surface located below the kick holes and are the best evidence of drywood termite presence. The more concentrated the pile, the closer the kick hole is located to the surface below. If the pellets fall several feet, they are spread out and form indistinct piles. In comparison to other termites, drywood colonies are rather small (a few thousand individuals). However, as swarming takes place within a structure, many new colonies will *be formed until a dwelling generally becomes* infested. Unless the entire structure is fumigated, it is usually impossible to delimit the infestation without removing plaster from the inside, or siding from the outside. The latter procedure is rarely used today.

I. minor swarms during the daylight hours, usually during the months of September and October is Southern California. Essig (1958) states that this species will swarm during the month of July in Arizona. They fly into attics or substructural areas of poorly vented houses. A favorite place for entry is in the crack created by drying plaster as it pulls away from window and door frames. It is necessary for most termites to be able to get a purchase (mechanical aid) on the wood that it intends invading. Normally, termites will not just land on wood and tunnel. However, if they can crawl down into cracks and crevices, there is not a problem with excavation.

Dampwood termites are of minor importance from a world standpoint, but they form a distinct habitat group. Dampwood termites locate their colonies in damp, often decaying wood; but once established, they can extend their activities into sound and even relatively dry wood (Fig. 51). They enter wood directly at the time of swarming and always confine their work to wood. They are occasionally responsible for serious damage to wooden structures, usually in conjunction with fungus attack, since the moisture requirements of both are similar.

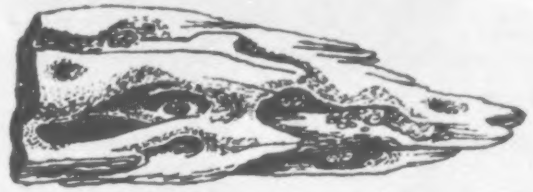


Figure 51 – Typical Feeding Damage of Dampwood Termite

Flights (swarming) of the dampwood termites are usually crepuscular (dusk). Some flights occur throughout the entire year; however, peak annual swarming takes place in late summer and fall. In Northern California and the Pacific Northwest, Zootermopsis augusticollis, the Pacific dampwood termite, and Z. nevadensis occupy a similar range; the latter predominating in cooler, drier, higher areas. Z. angusticollis extends southward along coastal California and eastward along the damp stream beds of foothill canyons and on into the mountains.

The winged reproductive Z. angusticollis may be an inch or more long, including the wings; the wings are from 7/8 to an inch long. The body is light cinnamon-brown; the wings are light to dark brown, heavily veined, and leathery in appearance. The soldiers (Fig. 52) are 3/8 to 3/4 inch (or more) long, depending upon the instar in which they assumed their typical soldier characteristics. This varies with the age of the colony, which is somewhat true of many species of termites (Fig. 53). As with other members of this family, there is no worker class. The nymphs and dealated reproductives are about 1/2 inch long.

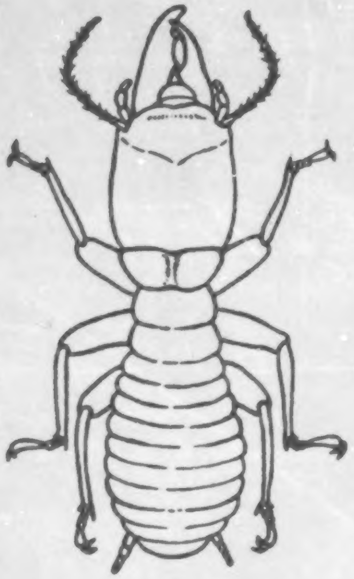


Figure 52 - Dorsal View of the Soldier of the Pacific Dampwood Termite

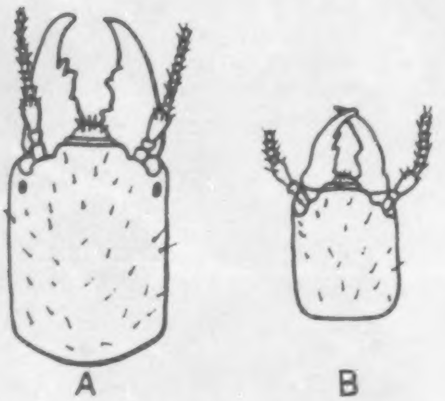


Figure 53 - Heads of Soldiers of Kalotermitidae
A. Incisitermes minor from old colony
B. Soldier of I. minor from a young colony

WOOD BORING BEETLES

Beetles belong to the largest order of insect in the world. The order is called Coleoptera, which means leather wing. This refers to the front wings which are chitinous (hard substance in the insect skeleton) and cover the abdomen (Fig. 54). Beetles have complete metamorphosis. The young (just as in termites) are typically the damaging stage. Pupation usually occurs in the wood in which the larvae feed. This so-called resting stage lasts, for most wood infesting beetles, about 10 days to 2 weeks. It is not actually a resting stage, but nature's way of changing a worm-like grub into a completely different appearing adult beetle with wings.

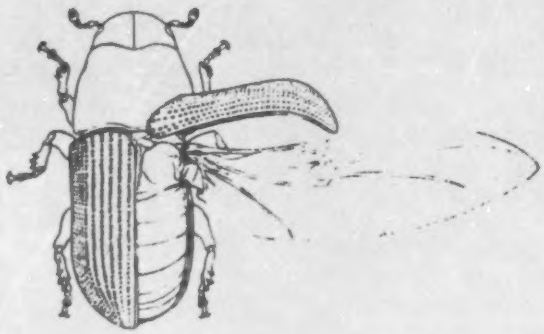


Figure 54 - Dorsal View of Beetle Showing Front and Hindwing

BEETLES THAT REINFEST

There are 3 important families of beetles that not only continue to reinfest, but frequently reduce the wood products to a powder if left undisturbed. They are called powderpost, or false powderpost beetles. They belong to the families Anobiidae, deathwatch beetles; Bostrichidae, branch and twig borers, and Lyctidae, true powderpost beetles.

Deathwatch Beetles

The common name applied to these beetles is the result of an old superstition. Years ago, when homes were built mostly of wood, they would become infested with anobiid beetles. At mating time, the sex call of the beetles consists of a tapping noise made by striking a part of the body against wood. In some instances, this tapping was taken as a sign which foretold of the death of a member of the household. Naturally, as one would sit up with those near death in the late of night, there was enough silence within the house to actually hear a number of these wood boring beetles calling their mates.

The anobiids are small (1/16 inch to 3/8 inch) and when viewed from above, the head is entirely hidden under the hood-like thorax (Fig. 55). The body is quite cylindrical. The 11-segmented antennae are inserted at the sides near the eyes with the 3 terminal segments somewhat enlarged forming a club. The larvae are humpbacked in appearance due to the enlarged thoracic segments. As indicated briefly in the key, the pellets are left in galleries in isolated clumps of different sizes (Fig. 7 of key) with galleries traveling both with and against the grain.

The western deathwatch beetle, Trypopitus punctatus, has been found destroying oak flooring, hardwood finish, and furniture. The softwood powderpost beetle, Hadrobregmus gibbicollis (Fig. 55) mines maple and wild prune in nature. However, the damage they cause is mainly from their attack on douglas fir. They have been found mining in timbers of bridges and under buildings. Such materials may be so completely mined as to require complete replacing. Although the soft parts of the timber may be mined first, eventually, the entire interior will be reduced to powder. This pest is most frequently associated with moist wood being attacked by wood rotting fungi.

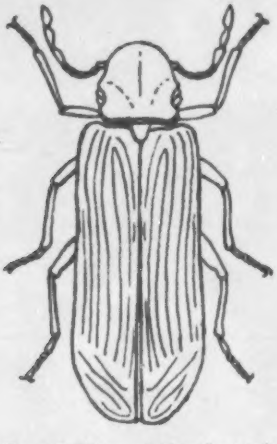


Figure 55 – Dorsal View of Deathwatch Beetle, Hadrobregmus gibbicolis

BRANCH AND TWIG BORERS

These insects are also called "false powderpost beetles." There are 2 species in this family (Bostrichidae) that cause structural problems, the lead cable borer, Scobicia declivis and the black polycaon, Polycaon stouti. The first species is quite typical in shape and appearance (Fig. 56) to other members of the family. The lead cable borer adults infrequently bore into lead sheathing of telephone cables leaving holes up to 1/8 inch in diameter. Rain and other moisture sources enters into the cables through these holes and may cause telephone service disruption through short circuits. This species normally attacks maple, oak, and other hardwoods in nature. The head is lodged in the spherical pronotum like a ball and socket joint, making it impossible to see the head from above. The last 3 segments of the antennae are distinctly enlarged. Adults are dark brown to black and about 1/4 inch long. This pest may easily be confused with adults of the bark beetle.

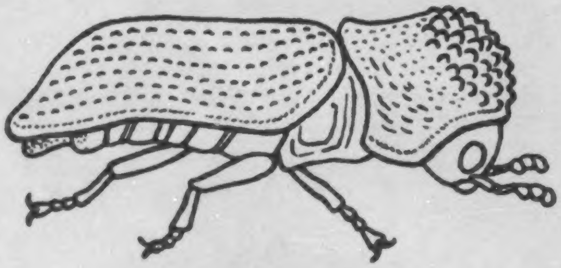


Figure 56 – Lateral View of Adult Lead Cable Borer, Scobicia declivis

As is typical of most members of this family, the eggs of the lead cable borer are deposited in old larval galleries or any crack and crevices in wood into which the adult female is able to crawl. The larvae primarily mine the wood with the grain. An emerging adult will turn at right angles from the larval mine and work its way out of the wood. The larval galleries are tightly packed with frass which is left as the young work through the wood.

The black polycaon adult does not have the typical family shape (Fig. 57). The life cycle is similar to that of the lead cable borer. The adult is a black, stout beetle, 3/4 inch long. The larvae tunnel in dead oak, maple, alder, eucalyptus, sycamore and other western hardwoods in Oregon, California and Arizona. The species has caused considerable damage to furniture and hardwood veneer plywoods. It also bores in rustic work, logs of cabins, and hardwood lumber when stored for a considerable time.

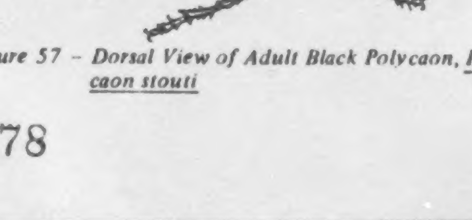


Figure 57 – Dorsal View of Adult Black Polycaon, Polycaon stouti

TRUE POWDERPOST BEETLES

The members of this family are from 1/8 inch to 5/16 inch long, somewhat flattened and from light brown to black in color (Fig. 58). The head is prominent and not covered by the pronotum. The antennae are 11-segmented and the club is rounded consisting of but 2 segments. The head being visible from above will separate members of this family from most other so-called powderpost beetles.

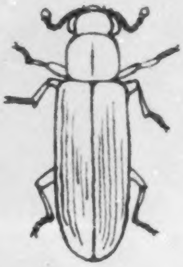


Figure 58 – Dorsal View of Adult Powderpost Beetle, Lyctus planicollis

In nature, these beetles breed in old, well-cured wood, but are frequent household pests working in furniture, flooring, tool handles, and other hardwood products. There is no way to visually determine the presence of an infestation until the first adults emerge through the wood surface creating pin holes.

The females lay eggs in the pores of the end cuts of the wood. These pests do not attack soft wood (e.g., pine, douglas fir). This may be associated with the lack of suitable pores in these wood and hence egg laying sites (Fig. 59). Solid and veneer ash is a favored wood for kitchens and other areas of southwestern homes. This wood is also favored food for several species of lyctid beetles. The starch content of the wood appears to be a primary basis for selection.

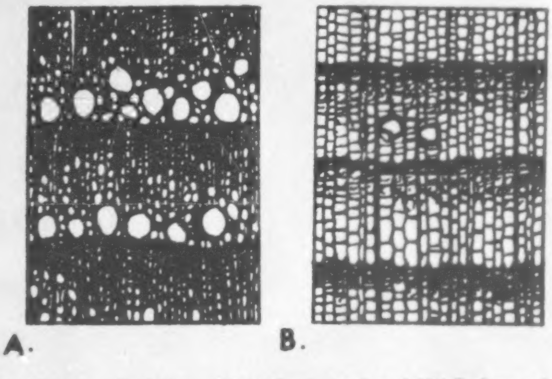


Figure 59 – End Cut of (A) Hardwood and (B) Softwood Showing Presence and Absence of Pores for Egg Deposition by the Powderpost Beetle

The southern and western lyctid beetles are the most common and troublesome species. These destructive beetles require approximately one year to complete a life cycle from egg to adult. In an in-house infestation, eggs may be laid during any month of the year. In nature, eggs are laid normally during the spring

BEETLES THAT CANNOT REINFEST

There are a large array of beetle familes that infest wood in nature. They attack forest trees in all stages of vigor, but tend to concentrate on weakened trees. The larvae and occasionally other stages of these families may end up in timber products and find their way into structures of one kind or another. Most of these families are unimportant, but there are at least 3 which are of continuous concern to pest control operators. Some of the most perplexing problems are created by the beetles that lay eggs within bark crevices on trees that are freshly cut. Their offspring can complete their life cycle in uncured lumber and frequently are "built into homes" and eventually emerge as adults from beam ceilings and subflooring through polished hardwood flooring, other floor coverings and wall plastering. Since these adults cannot find a suitable place to lay eggs within a man-made structure, they perish. These beetles which are commonly called flatheaded borers, roundheaded borers, and bark and timber beetles must have bark, the cambium layer, or living sour sap xylem (wood) for the placement of eggs. None of these conditions normally occur within man-made wooden structures.

METALLIC WOOD BORERS

These are brightly colored, beautiful beetles (Fig. 59), particularly when found in nature. As larvae, they are called flatheaded wood borers (Fig. 60). The head of the larvae is much wider than it is thick. The adult female must have bark upon which to lay eggs, which are wedged into crevices or under bark scales. Eggs are deposited in the spring and summer. The most damaging species of flatheaded borers are those with long life cycles, and the larvae may remain for years before becoming an adult. Often, the cycle is of such a nature that adults commence emerging not long after structural timber (2 x 4's, 4 x 4's or larger stock) is used. The home buyer suddenly realizes that his home is infested with beetles. Most Buprestidae adults are large, from 1/2 inch to 2 inches in length. The large size makes it difficult to miss these beetles when they begin emerging from walls.

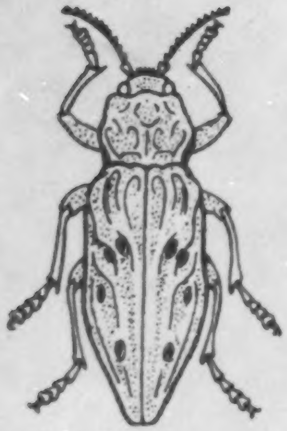


Figure 60 – Dorsal View of Adult Metallic Wood Boring Beetle

LONG HORNED BEETLES

Their name comes from the fact that the antennae of these beetles are usually as long or longer than the entire body (Fig. 61). The larvae are called roundheaded borers. For all practical purposes, the habits of this family are very similar to the flatheaded borers. The adult female must have bark upon which to deposit eggs. Burned, injured, or downed trees and saw logs are most attractive. Man frequently finds it convenient and inexpensive to harvest timber which has been injured in some way. As a result, these harvests result in lumber which may be infested by some kind of wood boring beetle. Some members of this family, the long horned beetles, are among the largest insects in the world.

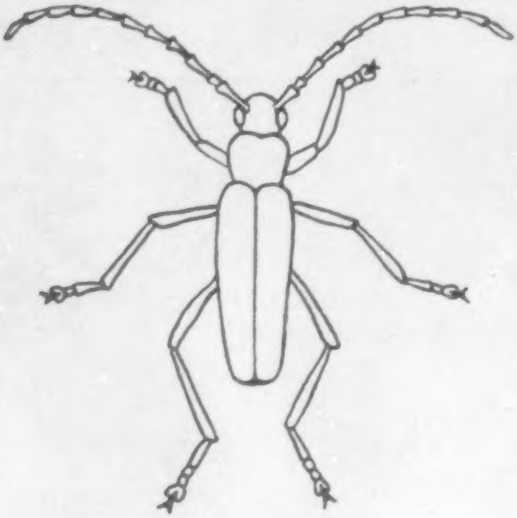


Figure 61 Dorsal View of Adult Long Horned Beetle

BARK AND TIMBER BEETLES

The bark beetles feed in the larval stage on the cambium layer (the layer of cells growing in between the wood and the bark) of woody trees. The adult timber beetles (Fig. 62) penetrate the sapwood when the tree is in a sour sap condition; (i.e., the sugar and starch in the sap has commenced to ferment). Ambrosia fungal spores are brought in with the adults and grow on the fermenting sap. The larvae are fed on the spores produced by the fungus. The fungus frequently stains and downgrades the quality of the wood. Both hardwoods (oak, black walnut, pecan, ash, birch) and softwoods (douglas fir, pine, spruce, cedar) are subject to attack.

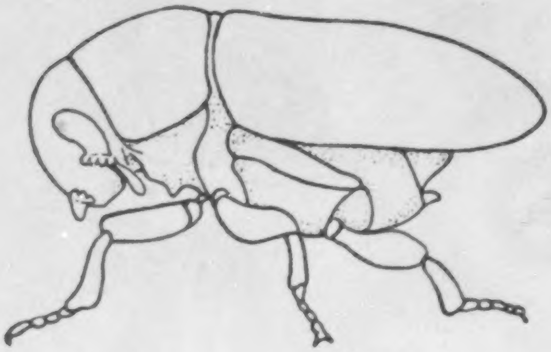


Figure 62 – Lateral View of Adult Bark Beetle

As with the 2 preceding families, attack must commence in the forest. If adults emerge in homes of other structures, they are attracted to windows or other areas of light. Large numbers of these beetles may emerge in a home when an individual cuts down a tree, chops it into cord wood and leaves it exposed to nature just long enough to attract bark or timber beetles. Then the wood is brought into the wood storage area, usually in a basement. Once the eggs hatch and the larvae feed to maturity and pupate, thousands of adults will soon emerge. This frightens the home owner and sometimes the pest control operator. Remember, bark beetles will not reinfest.

BEES, WASPS, AND ANTS AS TIMBER PRODUCTS PESTS

HORNTAIL WASPS

One of the wasps frequently encountered in wooden structures belongs to the family Siricidae (horntail wasps). The larvae are all wood borers or live in the stems of plants. Many forms bore into the trunks of living and dead trees and may end up like flatheaded or roundheaded borers "built" into a house. When they reach maturity, the wasp adult leaves the wood, frequently emerging through plaster or other penetrable substances. Emergence holes should be filled and resurfaced to match the surrounding area.

CARPENTER ANTS

Carpenter ants are frequently found emerging from wooden structures. In the eastern United States, these pests work wood much like drywood termites. On the West Coast, carpenter ants ordinarily do not cause economic damage to wooden structures but typically occupy nests abandoned by other organisms. Old drywood termite nests are frequently occupied by a number of species of carpenter ants. Carpenter ants are meticulous; they clear everything from the galleries. Thin and unwanted partitions are removed, but the gallery is not enlarged to any great extent (Fig. 18' of key). Their cleaning activities create distinct piles of different kinds of pellets, chips of wood, and other debris. Such piles are placed in locations near the nest and are diagnostic of carpenter ant infestations.

The workers are found at night roaming around various areas searching for sweets of one kind or another. These pests do not eat wood. The workers are large, long legged and black to brown in coloration (or some combination of the 2 colors)(Fig. 63). Several sized worker adults may occur in one colony. Usually, one must find the piles of frass in order to locate the small doorways through which they travel. If there are too many ants and all their locations cannot be found, fumigation might become necessary.

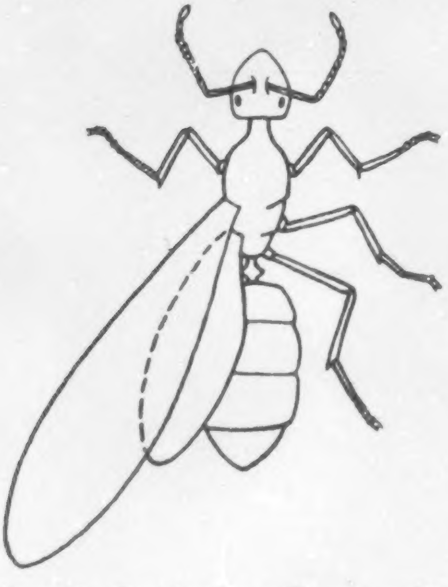


Figure 63 Semi-diagramatic Illustration of Carpenter Ant

CARPENTER BEES

Carpenter bees prefer soft woods (Fig. 64), but occasionally go to harder woods as eucalyptus. There are 3 species in the western United States, none of which cause serious damage, except to isolated structures. Mountain cabins and bridges built with redwood, tend to be most subject to attack. Piles of pencil shaving-like frass are frequently found near gallery entrances. Their attacks are periodical, and environmental conditions strongly control their response to certain kinds of wood. For example, following flood years in many of the canyons containing native white or creek alder, there becomes available a large quantity of the mountain carpenter bee's favorite colony-building wood. Less desirable wood, found in structures, would tend to be ignored under these conditions.

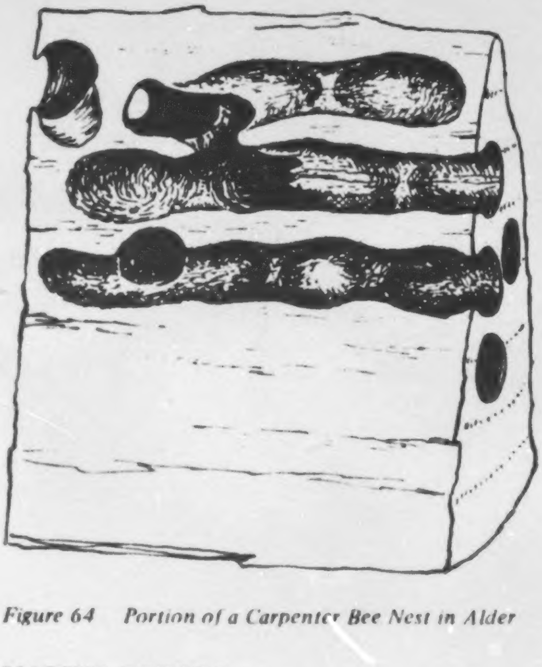


Figure 64 Portion of a Carpenter Bee Nest in Alder

MARINE BORERS

Marine borers have been a source of damage in all parts of the world since man took to sea in boats or built structures which came in contact with salt water. In favored localities these wood pests occur in countless numbers and work with a rapidity seldom met, even among insects.

Marine borers belong to 2 distinct classes of animals, the Mollusca (bi-valves) and Crustacea (crabs, lobsters). Most of the wood boring mollusks belong to one family known as Teredinidae. This family is composed entirely of burrowing species which typically drill tunnels in wood and line them with a thin layer of shell-like substance. Such tunnels may have a length of 4 feet or more (Fig. 16 of key). Each species excavates a mine which is quite characteristic in size and shell-lined appearance. The borers have long slender bodies, small shells and a pair of plumose or, paddle-shaped pallets near their siphons. Their pallets serve to close or plug the opening at the outer end of their burrows to exclude intruders. The food of these marine animals is plankton; therefore, their work in ships, pilings, and wharfs is for reasons similar to carpenter bees, simply a place in which to live and from which to feed. For example, the giant pileworm will completely destroy untreated pilings in 6 months under favorable conditions.

FUNGI ATTACKING WOOD PRODUCTS

Wood decay is caused by minute plants called fungi, These plants consist of microscopic threads that are only visible to the naked eye when many of them occur together. The fruiting bodies (deadwood conks, mushrooms) of fungi from which their spores are distributed are easy to see. Some fungi merely discolor wood, but decay fungi destroy the fiber. Decayed wood is often dry in the final stages, but not while the decay is taking place since these fungi require considerable moisture (Fig. 2 of key). Therefore, there is no such thing as "dry rot," and decay is a minor problem in the driest parts of the country.

Spores or "seeds" of decay fungi are always present in the air; they can't be kept away from wood. But fungi can grow in wood only when it contains more than 20% moisture. Air-dry wood is regularly below this danger point. One should particularly avoid infested lumber that is wet. It is especially dangerous where the lumber is so enclosed that it cannot dry. Wood infested heavily by stain fungi should also be avoided since it often contains decay fungi as well.

SOURCES AND CAUSES OF STRUCTURAL PEST PROBLEMS

Water and Moisture

The control of the presence of excessive water, no matter where it comes from, is of primary importance. Rain, water of condensation, water run-off (particularly where drainage and grade is poor), excessive ornamental plant irrigation, atmospheric moisture and leaky plumbing are a few examples of water sources. If water problem sources are ignored, serious structural damage will invariably result.

Using excessive water to irrigate plants adjacent to dwellings and other structures is a common practice in many of the dry areas of the southwest. In Hawaii, soil water is ever present, providing an optimum and continuous supply of needed water to the Formosan (and other) subterranean termites. Deep soaking of shrubs and trees growing near wooden structures gives the subs the moisture they need to commence, and maintain, a large colony. Controlled watering of plants is vital to the minimization of structural pests.

Faulty plumbing is another source of extraneous water which can be very simply controlled. If water is coming from leaking plumbing (a frequent defect) and the source can be located, the leak can be terminated. The 2 most common leak sources are improperly installed shower pans and toilet stools.

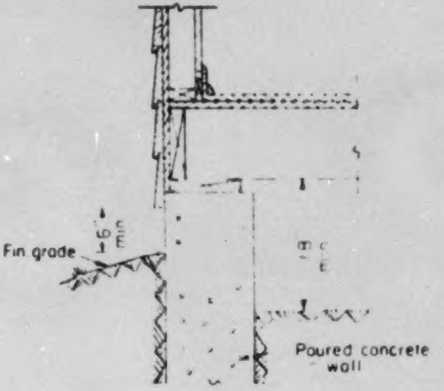


Figure 65 Diagram Showing Proper Finished Grade with Slope Away from Foundation.

Another common source of water is faulty grade of the soil in and around structures. Figure 65 shows grade sloped away from foundation. For example, in one instance around a Southern California home, when it rained, the run-off made its way around the house through the crawl space and hence into the earthen-floored basement. The unusual amount of water in this situation caused several posts supporting the substructural timbers to sink into the mud. It wasn't long before subterranean termites began to appear in abundance. The sinking of the posts (4 x 4.s) was so great that a number of doors on the first floor of the dwelling could not be closed. In this particular case, the poor grade and several structural mistakes cost the home owner considerably for the repair and corrections. When dealing with problems caused by unnecessary water, one must use ingenuity and thoroughness. Many times, terminating the water source completely eliminates the structural pest problems.

Exterior moisture may also be due to a downspout emptying in a spot where drainage is poor, high wet soil in a planter, seepage created by a high angle slope above one side of the house, high exterior grade, vertical cracks in the foundation, low ventbases permitting moisture to flow under the house, cracked away vent-wells, large vertical openings on either side of a chimney set in the foundation and many other similar situations. If a house is located near the coast, moisture from the heavy, wet fogs is sucked in under shingles, keeping the outer eave sheathing damp.

Soil Problems

Soil types, textures, depths, and chemistry are all closely related to moisture problems. Obviously, some soils will hold more moisture than others. There are sandy soils that will hold so little water that termites (subs) are unable to survive. For example, where structures are built on old river beds and washes, subterranean termites are usually absent. However, there may be areas immediately adjacent where natural water courses have laid down thick layers of silty, clay loam where subs abound.

Earth to Wood Contact

If proper soil conditions prevail, any direct contact between earth and wood is an invitation to attack by subterranean termites and fungus decay. Some earth to wood contacts are readily visible and some may be inaccessible.

Around the exterior of a building, w[illegible]ay find any of a number of wooden structures [illegible]ntact with the ground. These may include wo[illegible] a vent-frame, a fence or gate post attached to [illegible] house or to the garage, wood siding, flow[illegible] boxes, masonry planters, lower steps of wo[illegible]n stairways, trellis stakes, wooden dividers be[illegible]en concrete or masonry squares in a patio, w[illegible]oden or stucco-covered archways, carport supporting post, and many others too numerous to mention.

If a house has a crawl space some of the many possibilities of earth-to-wood contacts include stakes (either grade or form supports), temporary wood posts left in place under hearths or under heavy appliance installations, angular bracing extending into the soil, wood and paper boxes used as storage under houses, wood blocks supporting plumbing and or heating ducts, and earth-filled porches and patios where the earth makes contact with some part of the wood framing of the substructure (Fig. 66).

Slab on Grade Construction

Slab on grade construction may also have problems from the subterranean termite attack. When not monolithically poured, shrinkage cracks often occur between porches or patios and the main

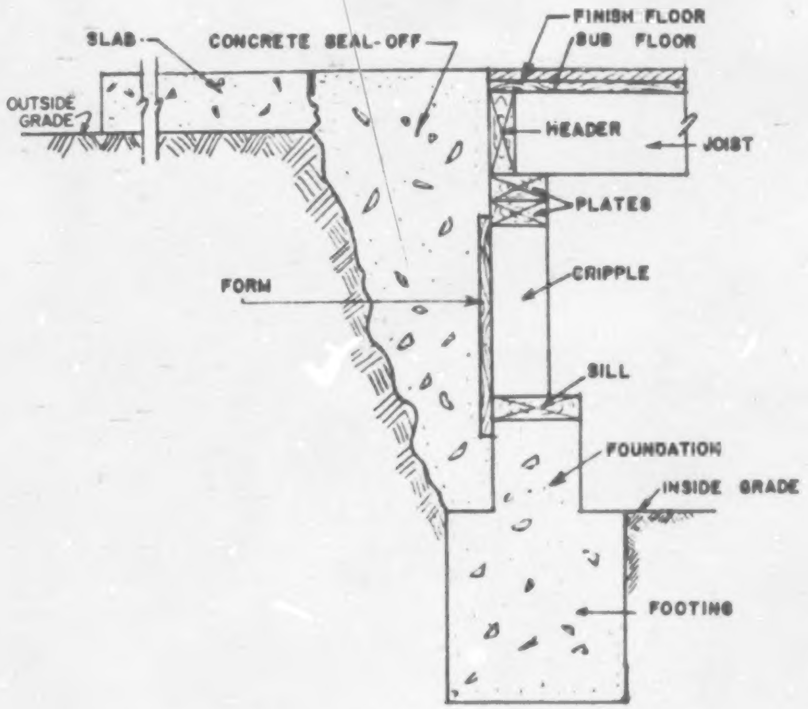


Figure 66 One of the Most Common Sources of Subterranean Termites Attack is an Earth-Filled Porch Which is not Properly Sealed. A Concrete "Seal Off" is Used to Seal the Foundation Away from Earth-Filled Porches.

floor-slab in modern concrete slab construction (Fig. 67).

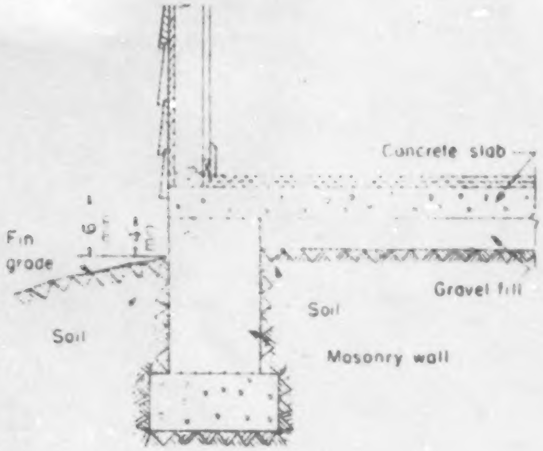


Figure 67 *– Suspended Concrete Slab-on-Ground Construction Generally are more Susceptible to Subterranean Termite Attack Than Monolithic Slab Construction*

DRYWOOD TERMITE ATTACK

The dead limbs in fruit, nut and ornamental trees are often attacked by drywood termites. When such trees are in close proximity to a structure, they constitute a definite hazard. Drywood termites may build up in these materials and then migrate to structures. When old utility poles are within a 100-foot radius of a structure, they are hazardous especially when not properly treated chemically. Infested fences and temporary type structures (such as storage rooms, play houses, tool sheds) may be sources of infestation by these termites. During the primary swarming period of August through November, the winged reproductives of the drywood termite often concentrate their attack on piles of newly milled dimension lumber at the site of new construction.

INSPECTION TECHNIQUES

The material presented in this section is based on *Inspection for Wood Destroying Organisms*, Ronald W. Hunt, Sr. 1966.

EQUIPMENT

A good light is essential and most inspectors prefer the five-cell flashlight. Extra batteries and bulbs for the light may often prevent unnecessary delays. A heavy jackknife, an ice pick or a small wood chisel for probing into the wood is also a necessity. A thick piece of spring steel or a hacksaw blade is needed for testing earthfills. A screwdriver, measuring tape and hammer should be included with the equipment. A light, strong 6-foot stepladder is essential. Coveralls, a stocking cap, gloves and sponge-rubber kneepads make up the balance of the essential equipment. Persons subject to dust irritation should also include a small compact respirator.

Some inspectors carry cameras with falsh attachments to photograph special conditions. A sizeable clipboard equipped with cross-section paper is handy to sketch a diagram of the structure and make notes of findings. Finally, a whisk broom, some waterless soap and a supply of clean rags are additions to include with the equipment.

PROCEDURE

Procedure will be divided into 4 parts: the examination of the exterior, the interior, the attic and the substructural area. Before proceeding with the inspection, the inspector should explain his mission to the occupant. A few questions concerning his or her observations regarding insect occurence, damage, plumbing leaks or other irregularities, may be very helpful.

Exterior Examination

Walk slowly around the structure pacing off the approximate measurements and draw a rough diagram. By using "engineering" cross-section paper which is laid out on the decimal system, the inspector will find it easier when totaling the lineal feet. Set in the porches, patios, vents, vent-wells, columns and pilasters. Also record the moist areas, exterior grade conditions, vertical foundation cracks and exterior earth-to-wood contacts. If the structure is stucco finished, tap the stucco below the top of the foundation with a heavy pocket knife, hammer or some object heavy enough to produce a hollow sound if the basal stucco is loose.

This phase of the inspection if very important whether the structure is on a slab or is a crawl-space type. Many of the earlier concrete slab-type houses have an exterior plumbing vent or hatch which should be removed and the inside checked. Many of the older stucco finished structures were decorated with columns, pilaster and arches as well as buttress-walls; these were not always provided with a proper footing and should be checked. If the footing conditions are doubtful, it may be necessary to recommend opening and would thus necessitate an additional inspection with supplemental report. Note shrinkage cracks between the foundation and such attachments as concrete porches, patios, vent-wells, masonry or concrete planters, stone facings, and masonry chimneys.

The size and condition of substructural ventilators is a must in the case of F.H.A. inspections or where Uniform Building Code requirements are present. The condition of the crawl-vents is of primary importance if small children or animals are to be kept out of the sub-area. If the vent-frames are of wood, note deterioration or exterior earth-contact. Where shrubbery is dense adjacent to the structure, ventilators may be partially or completely blocked.

Don't forget to look up as well as down! The wood structure in the eave-area may show indications of drywood termite colonization or fungus decay. The excrement pellets of drywood termites are quite often caught in spider webs or a few may be resting on a projecting ledge. In coastal locations check the outer eave-boards, where moisture collects and fungus infection is likely to occur. Watch for clogged "valleys" and eave-troughs. If it is a two-storied structure and suspicious discolorations are in evidence, inspection from an extension ladder is indicated. In two-story apartment buildings, front, rear or side stairways are provided for access to the upper level. If either the stairs or stairlandings are enclosed by stucco, be sure to note the presence or absence of access doors and/or ventilation of the enclosed portions. If found to be inaccessible, these enclosed areas may be seriously attacked by either fungus, termites or both. During these exterior observations, make careful notations on your diagram and do not trust your memory as findings in other areas may distract you and earlier observations may be forgotten.

Exterior inspection of houses with concrete slabs is similar to crawl-space houses but there are certain points which should be stressed. The combination of high exterior grade and loose stucco is "dynamite" in slab construction. Planters are more often a hazard and vertical cracks in the main slab may result in both moisture penetration and infestation by subterranean termites. Open and inspect plumbing hatches and electrical meter and fuse-boxes. Normal shrinkage cracks between porches and patios and the main slab should be inspected. Be sure to check concrete attachments installed by the owner. If these are poured without prior stucco removal they may present a serious hazard. Fence and gate posts adjacent to a slab-type house are hazardous, especially where the soil is built up in gardening.

Inspection of the Interior

Generally speaking, the condition of plumbing fixtures and plumbed appliances are the most important part of interior inspection. Although the stall shower is most often the prime offender, the inspector should not overlook a built-in tub which may have insufficient wall protection or calking. A leaking dishwasher, washing machine, water heater, garbage disposal and/or the drainage system under sinks and washstands are always suspect.

Leakage of stall showers is a prime source of moisture accumulation. Many operators prefer to test for leakage by bucketing in the water for floor, pan and subdrain testing. Then, after checking conditions in the sub-area beneath the shower they return to the bathroom and open both shower valves. Leaks in valve-packing and wall-tile penetration will seldom be missed if this is done. Don't forget to check the toilet stool for leakage. This latter type of leak has the potential to rot out the entire bathroom floor in crawl-space houses. In homes built close to the ocean or inland salt water bays, the oxidation of iron water pipes is very rapid and leakage in the wall areas is frequent. Wooden window sashes are always subject to moisture deterioration and the attacks of drywood termites. In the interior valleys, the putty dries and cracks, permitting the rain and condensation moisture to accumulate in the glass channel.

Interior inspection of houses on slabs does not vary much from that in crawl-space homes. However, there are a few special points which should be stressed. Plumbing leaks will cause linoleum to loosen, asphalt tile to buckle or produce stains. Plumbing or conduit openings through the slab are points of entry for subterranean termites. These plumbing hatches may reveal fungus damage, subterranean termite activity, earth-contacts due to burrowing animals or leaking pipe joints.

The Attic Area

Indications of drywood termite attack such as wings or frass, may often be found even though no piles of pellets or active colonies are located. The tops of ceiling-joists, the button lath or batt-type insulation directly beneath the ridge-board and the area adjacent to or just beneath attic vents are locations one should always check for drywood termite pellets, wings and/or frass. If you note what appears to be a pile of sawdust on the upper plate near the eaves and you find it impossible to get close enough for a good look, moisten your hack saw blade and pick up a sample for accurate identification. Fungus infections due to roof drain stoppage may be in evidence in these areas. The presence of buckets, pans and the like found in an attic generally indicates roof leaks. It is not uncommon to find shelter tubes of subterranean termites in portions of the attic directly above earth-filled porches, hearths and closed in concrete patios. In recent years the presence of wood-boring beetle damage in the attic area has become more noticeable. Some of this damage may have occurred in the forest but the extensive building program of the last few years has allowed less time for lumber curing and active beetle colonies are not uncommon. This is especially true in the case of bark beetles.

While in the attic, it is a good idea to note any evidence of household insects or rodents. In many areas, opposums and even skunks have taken up residence in the attic areas of older, vine-covered frame houses. Silverfish, cockroaches, hornets, wasps, honey bees and especially birds and bats are frequently found in attics. When you have completed the inspection of the attic, obtain a moist cloth so that you may remove the finger marks from the exposed portion of the attic hatch.

In the event that no way of access into the attic can be found, estimate its accessibility from the exterior and recommend the cutting of a hatch if you are satisfied that sufficient clearance exists. Sometimes excessive bracing, roof additions and blown-in insulation limit the accessibility of the attic area and these facts must be set down in the notes. If the simple removal and replacement of a single brace or the opening of an abandoned roof section is all that is necessary to make the entire attic accessible, do not shirk your responsibility by failing to examine it

Crawl-space Inspection (Substructural Area)

In the past, the conventional pattern of the sub-area inspection was nearly always made in a narrow path around the under area adjacent to the foundation. An exception would be in the case of large buildings where cross-walls interfered. Although cross-walls are utilized under single story structures, they are always found under bearing partitions in buildings of 2 or more stories. In contemporary homes, many things interfere with the so-called "conventional pattern." These interferences are the relocation of appliances such as automatic washing machines, driers, water heaters and dishwashers and the fact that bathrooms are not always contingent with the foundation as they always were in the past. Leaking water lines and plumbing connections may now occur several feet away from the foundation. Some of the worst offenders are side-opening dishwashers and condensation water in both washing machines and dishwashers where ventilation is defective. This permits a build-up of steam pressure within the appliance. We can no longer be satisfied with the fact that the plumbing along the foundation appears dry. All this points to a wider path of inspection and a route beneath each bath, half-bath or relocated water-connected appliance. Having already examined both the exterior and interior, the inspector should have the strategic points well in mind. Most likely these will be the location of earth-filled porches, patios, embedded vent-frames, planters, damp areas, bathrooms and water-connected appliance locations.

The general practice in checking an earth-fill porch is to slip a thin metal probe under the mudsill (sill) to locate either a void or the fill itself (Fig. 68). If the probe penetrates the area beneath a porch cap freely, no "seal" exists, but if it strikes a hard surface back of the mudsill, a question arises as to the presence of a contact. In the latter case the earth-fill is either sealed off or some structure has interfered and the seal is questionable. Where a porch-seal is in question, make a diligent search for the presence of shelter tubes of subterranean termites before reaching any conclusion. Experience has shown that a probe may fail to penetrate all but a small sector so don't give up after a few tries . . . blade it all! Some inspectors use light colored chalk or crayon to make arrows on the foundation indicating penetration points or evidence of infestation. These are valuable guides when reinspections are made at later dates.

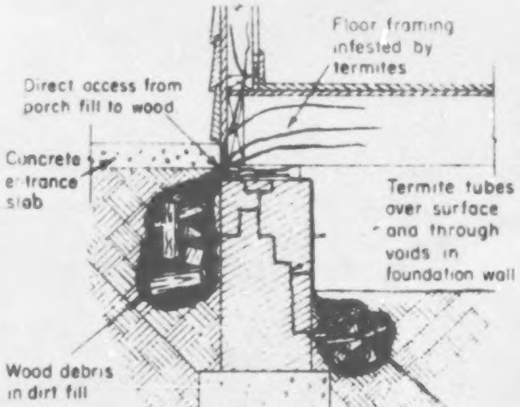

Floor framing infested by termites
Direct access from porch fill to wood
Concrete entrance slab
Termite tubes over surface and through voids in foundation wall
Wood debris in dirt fill
Wood debris in soil

Figure 68 – The Seal on an Earth-filled Porch is Checked by Slipping a Thin Metal Probe Beneath the Mud-sill (Indicated by Arrow).

Within reasonable sight-range, most vertical shelter tubes of subterranean termites attached to the foundation (Fig. 69) and free-standing swarmer tubes are readily visible. One must be much more alert to spot horizontal tunnels extended along the mudsill, in subfloor cracks, at the edges of blocking and those extending along floor joists and girders. If possible the latter should be traced to their point of origin. The colony may have originated in an earth-fill, an exterior planter, an embedded exterior vent-frame, a vertical foundation crack, some loose stucco, a wooden structure attached to the house or some other earth-to-wood contact.

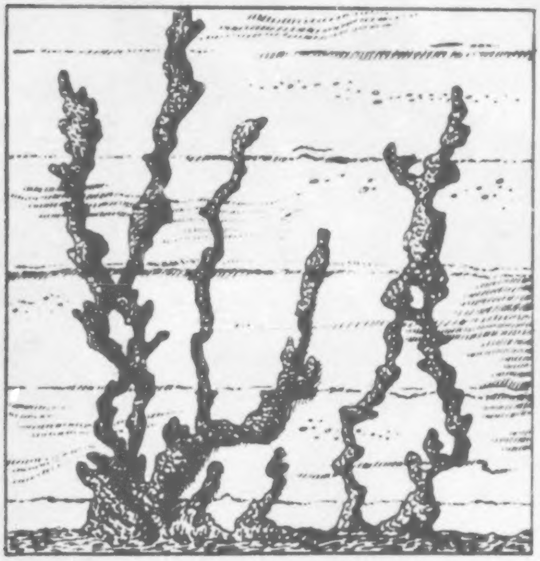


Figure 69 - Subterranean Termite Shelter Tubes Attached to Concrete.

As previously stated, good visibility cannot be obtained at distances of more than 15 to 18 feet. Therefore, if the structure exceeds 36 feet in width, 1 or 2 extra routes traversing the central portion becomes necessary.

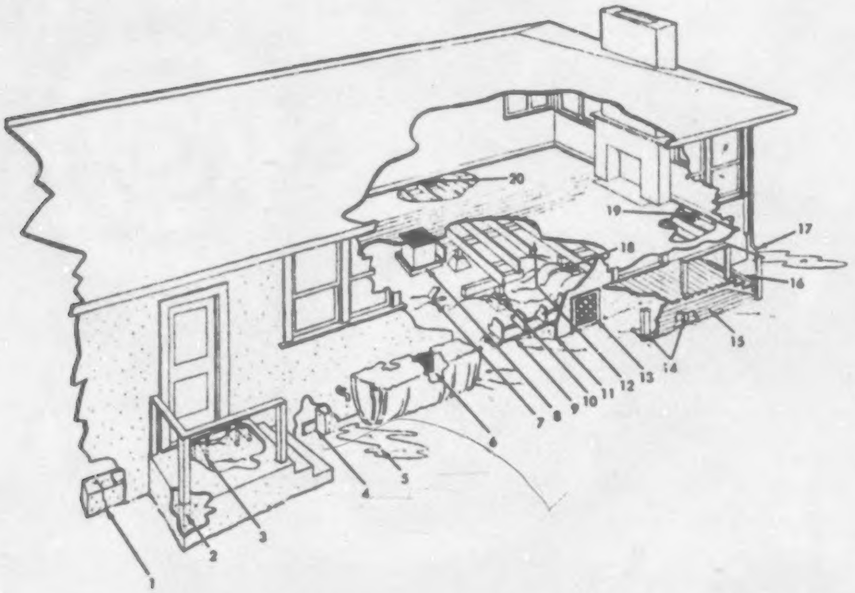
Known locations of drywood termite colonies in the periphery of the attic or at approximate interior locations help the inspector to spot accumulations of excrement pellets in the sub-area. Large piles of dropping spill over the mudsill onto the ground and are more easily discovered. Compact piles of drywood termite pellets indicate a source close at hand while scattered pellets suggest a more distant origin.

Some locations in the sub-area which should be given particular notice are: areas directly beneath floor furnaces, soil pipe openings through foundations, wood forms or stakes left in place by the builder, cellulose debris, tree stumps, plumbing or heating ducts supported on wood blocks, moist areas, vertical foundation cracks and piled up earth. Check carefully under the stall shower which has been previously water-tested. If it is damp or dripping, determine the source of the leak. Probe the subfloor for softness. This goes for stained areas whether dry or wet. Where one inch subfloor is used, it may be necessary to arrange the removal of a section to reach a verdict. Don't overlook the flooring and joists directly beneath the toilet stool. Although everything may look "ship-shape" in the bathroom, the real story will reveal itself directly beneath the stool. Dry dormant fungus decay beneath a toilet indicates that the toilet was re-set without floor-repair. Such a condition is a serious hazard because a new leak will reactivate the fungus development.

Garages

One of the primary problems involved in garage inspection is storage. If the inspector cannot reach all the strategic portions of the garage due to storage, make note of this and suggest a supplemental inspection and report when these can be made available. Sometimes garages are partially or completely "finished" on the inside and except for the door and door-jamb, a garage like this may be inaccessible for inspection. In the southwest where both subterranean and drywood termites occur, a proper inspection includes the mudsill, studding, upper plates, rafters and sheating. Flat roofed garages are subject to fungus decay adjacent to the drain or down-spout area. The header above the door is a spot that is easily missed, especially when there is an open overhead door. Shrinkage cracks adjacent to the foundation and diagonal cracks passing under the mudsill are definite garage hazards.

Some garage-owners have built-in colonies of drywood termites with infested shelving, storage rooms, benches and the like. Sometimes infested stored furniture, and firewood may be the source of the garage infestation of drywood termites or wood-boring beetles. Small temporary-type structures built onto the sides or rear of the garage may not be properly insulated from the ground. Where the garage is an integral part of the house, it becomes as important as any other portion. If the garage is used as a laundry, check all water-connected appliances. A locked garage generally means a supplementary inspection and report unless the owner refuses to permit the inspection. In this case, explain the circumstances in your report. High exterior grade conditions and piles of trash or stored lumber adjacent to the outer walls of the garage are definite hazards. The common points of faulty home construction are maintenance that may lead to infestation by wood destroying pest are summarized in Fig. 70.



1. CRACKS IN FOUNDATION PERMIT HIDDEN POINTS OF ENTRY FROM SOIL TO SILL.
2. POSTS THROUGH CONCRETE IN CONTACT WITH SUBSTRUCTURAL SOIL. WATCH DOOR FRAMES AND INTERMEDIATE SUPPORTING POSTS.
3. WOOD FRAMING MEMBERS IN CONTACT WITH EARTHFILL UNDER CONCRETE SLAB.
4. FORM BOARDS LEFT IN PLACE CONTRIBUTE TO TERMITE FOOD SUPPLY.
5. LEAKING PIPES AND DRIPPING FAUCETS SUSTAIN SOIL MOISTURE. EXCESS IRRIGATION HAS SAME EFFECT.
6. SHRUBBERY BLOCKING AIR FLOW THROUGH VENTS.
7. DEBRIS SUPPORTS TERMITE COLONY UNTIL LARGE POPULATION ATTACKS SUPERSTRUCTURE.
8. HEATING UNIT ACCELERATES TERMITE DEVELOPMENT BY MAINTAINING WARMTH OF COLONY ON A YEAR-ROUND BASIS.
9. FOUNDATION WALL TOO LOW PERMITS WOOD TO CONTACT SOIL. ADDING TOP SOIL OFTEN BUILDS EXTERIOR GRADE UP TO SILL LEVEL.
10. FOOTING TOO LOW OR SOIL THROWN AGAINST IT CAUSES WOOD-SOIL CONTACT. THERE SHOULD BE 8 INCHES OF CLEAN CONCRETE BETWEEN SOIL AND PIER BLOCK.
11. STUCCO CARRIED DOWN OVER CONCRETE FOUNDATION PERMITS HIDDEN ENTRANCE BETWEEN STUCCO AND FOUNDATION IF BOND FAILS.
12. INSUFFICIENT CLEARANCE FOR INSPECTION ALSO PERMITS EASY CONSTRUCTION OF TERMITE SHELTER TUBES FROM SOIL TO WOOD.
13. WOOD FRAMING OF CRAWL HOLE FORMING WOOD-SOIL CONTACT.
14. MUD SILL AND/OR POSTS IN CONTACT WITH SOIL.
15. WOOD SIDING AND SKIRTING FORM SOIL CONTACT. SHOULD BE A MINIMUM OF 3 INCHES CLEARANCE BETWEEN SKIRTING AND SOIL.
16. PORCH STEPS IN CONTACT WITH SOIL. ALSO WATCH FOR LADDERS AND OTHER WOODEN APPURTENANCES.
17. DOWNSPOUTS SHOULD CARRY WATER AWAY FROM BUILDING.
18. IMPROPER MAINTENANCE OF SOIL PILED AGAINST PIER FOOTING. ALSO MAKES CAREFUL INSPECTION IMPOSSIBLE.
19. WOOD GIRDER ENTERING RECESS AND FOUNDATION WALL. SHOULD HAVE 1 INCH FREE AIR SPACE ON BOTH SIDES AND END AND BE PROTECTED WITH A MOISTURE IMPERVIOUS SEAL.
20. VENTS PLACED BETWEEN JOISTS TUNNEL AIR THROUGH SPACE WITHOUT PROVIDING GOOD SUBSTRUCTURAL AERATION. VENTS PLACED IN FOUNDATION WALL GIVE BETTER AIR CIRCULATION.

Figure 70 – Twenty Points of Faulty Home Construction and Maintenance that May Lead to Infestation by Subterranean Termites. Illustration by Courtesy of the Eleventh Naval District, San Diego.

DAMAGE AND CORRECTION ACCORDING TO THE NATURE OF THE PEST

Once a thorough inspection has been completed and the structural pest control biologist is fully aware of the pest status and conditions likely to lead to pest infestations, decisions must be made to bring about effective control.

TERMITES

The basic control technique found to be most satisfactory for the control of subterranean termites is the provision of a chemical barrier between the soil (where the termite must return to obtain moisture) and the wood upon which they feed. This means preparing a small trench along all inner bearing walls and around pier posts. The trench needs to be only 2 inches or 3 inches deep. Once prepared the trench is flooded with an approved, residual chemical (Fig. 71). Some companies also provide added protection by drilling all bearing timbers (mudsills, pier posts, girders) with 1/4 inch holes (which do not quite go all the way through) and pressure impregnating them with chemicals.

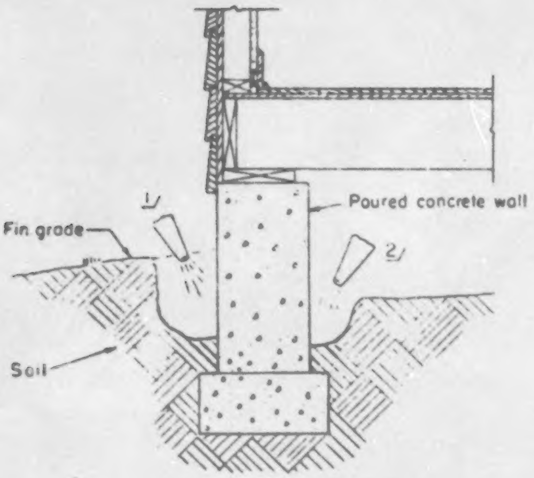


Figure 71 – Application of Chemical to Crawl-Space Construction. Soil Treatment (1) Along Outside and (2) Inside Foundation Wall.

In treating the substructural areas in conventional construction (i.e., areas under a house with sufficient clearance to crawl under for inspection), the removal of all organic debris is necessary. Such debris would include everything of wood or paper that is lying on (or is in contact with), the soil.

In slab on grade construction, termites can work their way up through the smallest of cracks in the floor. One application method that has come into use for treating this problem is drilling holes through concrete and masonry caps and walls and injecting of soil toxicants under pressure. Modern equipment has greatly facilitated this practice. When drill-treating is employed, always use a pressure-type slab injector and use as large a volume of material as possible. Soil types beneath the concrete or masonry caps should be considered, and the drilled holes spaced accordingly.

Structural Correction

Structural correction includes the installation of mechanical barriers between wood and soil to eliminate the penetration of subterranean termites and moisture, as well as the removal and replacement of wood members structually weakened by either termites, wood boring beetles, or fungus. Often this type of correction includes a combination of damage replacement and insulation.

Included in the barriers installation phases are the sealing-off of contacting earth-fills with concrete or masonry (Fig. 68), the installation of flash-walls, the plugging of hollow buttress walls and the pouring of concrete footings to insulate the bases of pillars, pilasters and stuccoed walls. This category also includes the raising of foundations, replacing wooden lower-steps with concrete and insulating embedded door-jambs, door casings and fence or gate posts which are fastened to structures. Concrete or masonry vent-wells, basal vent curbings, repalcement of loosened exterior stucco and the drilling and plugging of vertical foundation cracks should also be included.

The second phase of structural correction, which entails the removal and replacement of timbers weakened by the attack of wood destroying organisms, was at one time carried to extremes. In the case of subterranean termite attack, it is sometimes possible to reduce the magnitude of such an operation (after eliminating the source of infestation) by leaving the least damaged portion of the affected member in place and strengthening it by "scabbing on" a new and preferably treated member.

Due to its potential regrowth characteristic, fungus infection should be removed in its entirety wherever possible. After the source of moisture is eliminated, it may be feasible to reduce the volume of the reapir to some extent and prevent reactivity by saturation of the new and adjacent timbering with an oil soluble wood preservative. If it should prove impractical to remove some of the slightly infected timbering due to structural barriers, it would be justifiable to saturate the affected member with preservative to strengthen it where needed. In correcting fungus damage, it is always advisable to use pressure-treated replacement timber if it can be obtained locally.

When replacing wood siding on an older frame house, it is often necessary to have an obsolete type of siding milled to match. Most lumber yards can reproduce any type you need, but in small quantities, the expense is considerable. In stucco repair, always attempt to have both texture and color properly matched.

Drywood termites present quite a different challenge. If the "kick holes" can be found and the infestation delimited, infestations can be individually drilled and chemically treated. If the infestation cannot be delimited (i.e., if there are many small infestations evident in many areas and it is reasonably certain that drywoods are in the studding and other inaccessible areas), fumigation is absolutely necessary. Few cases warrant the removal of inside or outside plaster or siding. Tent fumigation has become routine for a general infestation of drywood termites. In garages where most of the structural woods are exposed, it is a simple matter to drill into the infested wood at

8-inch intervals and dust toxicants into these holes. This dust is picked up by the termites and spread throughout the colony.

In the case of beetles that reinfest, the infested lumber must be removed and replaced, spot fumigated, or the entire structure fumigated. If true powderpost beetles are found in tool handles or artifacts of one kind or another, placing these materials in an oven at 250°F. until the center of the wood has reached that temperature will kill all stages of development.

When treating infestations of deathwatch beetles (which prefers our common structural wood, douglas fir) a moisture problem can be corrected. posts and other timbers can be removed and replaced, or the wood can be spot treated with chemicals. Generally, if a structural member is at least one-half destroyed, it should be removed.

Non-reinfesting beetles and horntails are simply allowed to escape. The holes made by the adults, as they work their way out of the wood have to be filled and properly refinished. If it is obvious that such adults, like long horned beetles or metallic wood borers, are continuing to emerge as adults in ever increasing numbers, spot treatment to prevent further unsightly holes may be necessary. It is sometimes very difficult to detect the presence of these organisms during their milling operation.

The most important move with carpenter ants is to locate the gallery. Once this is done, 1/4 inch holes can be drilled at the proper locations and the gallery impregnated with toxicants.

If carpenter bee holes are found in bridge timbers, posts, garage studding, or other timbers, a number of toxicants can be applied into the exposed holes and then reseal them. Rarely is it necessary to deal with these minor pests.

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LEARNING AT HOME
Review Questions – Section 3

1. Termites are closely related to ________.
2. Termites belong to the order ________.
3. About ______ different species of termites have been described by Entomologists.
4. How many basic caste systems do termites have ________.
5. In some species there is a reproductive form called Tertiary, what is its function ______.
6. On an average less than ______ percent of swarming termites survive.
7. Which type of termite does not have a worker caste ________.
8. Wood is made up of 3 dominant ingredients:
   1. ____________.
   2. ____________.
   3. ____________.
9. Which of the ingredients in wood is taken for food by termites ________.
10. The ________ from wood is digested by an organism in the intestinal tract of termites called ________.
11. Worker termites may live ________ years.
12. The shape of the head of the Coptoterme forsanus soldier is ________.
13. The specie of the Eastern Subterranean Termite is ________.
14. When boring through wood the Western Drywood Termite tends to ________.
15. Which order of insects is the largest ______.
16. Beetles develop with ________ metamorphosis.
17. The shape of the body of anobiids is ____.
18. Bostrichidae beetles are sometimes called ________.
19. True powder post beetles attack only ____.
20. As larva, the metallic wood borers are called ________.
21. The larva of the long horned beetles is called ________.
22. The food of carpenter ants is ________.
23. Carpenter bees prefer ________ woods.
24. Wood decay is caused by minute plants without ________.
25. Name 3 common sources of excessive moisture in structures:
    1. ____________.
    2. ____________.
    3. ____________.

OUTSIDE ASSIGNMENTS

1. Collect at least 2 pieces of damaged wood and using the keys in this section, identify the damage.
2. Duplicate these keys or type them to allow pictures opposite the last key in a series and where a determination is listed, see how many pictures of the pests you can find. Paste them in and enter this in your note book.

PESTICIDE LABELING

Henry G. Schierenberg
Agricultural Biologist,
California State Dept. of Agriculture

INTRODUCTION

There is a definite need for increasing food, fiber, and forage production in the United States and abroad. There is also a need for continued and improved protection of public health because of the world population explosion. Both of these needs can be met, in part, by the judicious use of pesticide chemicals.

Ten years ago, 30 diseases had been reduced or eliminated in the world by the use of DDT and other pesticides to control insect vectors of these diseases. Among those controlled were vectors of malaria, dengue fever, yellow fever, bubonic plague and typhus fever. However, large concentrations of people under unsanitary conditions create an ideal environment for the spread of many diseases carried by mosquitoes, fleas, lice, and other insects. In the future, as the world population increases, and becomes concentrated into confined living areas, the potential for epidemics spread by insects and related organisms will increase unless we continue to have the ability to control these pests.

Although biological and integrated control play an important role in our overall control of pests, we must still rely, to a large extent, upon chemicals to control and suppress the majority of pests. Although we derive many benefits from pesticides and other agricultural chemicals, numerous problems are associated with their use, or more particularly, their misuse. DDT is gone and other pesticides are under attack. Many problems could be eliminated if those who use pesticides were better informed about safe methods of handling and application. Anyone who decides to use these chemicals, must accept the responsibility that goes with their use. These materials are poisonous to one or more forms of life, sometimes including our own. Only by proper and careful usage can the various hazards associated with the chemicals be kept to a minimum.

In 1972, Congress amended the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) of 1947. This amendment requires, by test and evaluation, the certification of applicators who use pesticides designated for "restricted" use. Commercial applicators will be certified in one or more use categories including industrial, institutional, structural and health related pest control. Included are commercial applicators using or supervising the use of "restricted" use pesticides in, on, or around food handling establishments, human dwellings, institutions such as schools and hospitals, industrial establishments including warehouses and grain elevators and any other structures and adjacent areas, public or private; and, for the protection of stored, processed, or manufactured products. This program will be in operation by October, 1976.

The aim of this manual is to assist members of the structural pest control industry prepare for the certification examinations. The outline of this section includes:

a) The general format and terminology of pesticide labels and labeling;
b) The understanding of instruction, warnings, terms, symbols and other information commonly appearing on pesticide labels;
c) Classification of the product, general or restricted;
d) Necessity for use consistent with the label.

DEFINITIONS

The Label is that information printed on or attached to the container.

Labeling refers to all other information printed and distributed to describe the product. This includes brochures, flyers and other information given out concerning the product. It must not differ in meaning from the information furnished to E.P.A. when the product was registered.

LABELS

Read the Label

Information on pesticide labels has been called the most expensive literature available. The research and development that lead to the wording on a label frequently cost millions of dollars. The combined knowledge of many workers in industry, universities and government is used to develop the information on the label. It has been estimated that it takes 10 million dollars and 10 years to develop an insecticide to the point where it bears a label.

The importance of reading the label cannot be stressed too often. The information that appears on the label is put there for your information and your protection. If it is read, understood and all of the directions are followed, the likelihood of misusing the materials or of having an accident with the pesticide is remote. The most important few minutes in pest control is the time spent in reading the label.

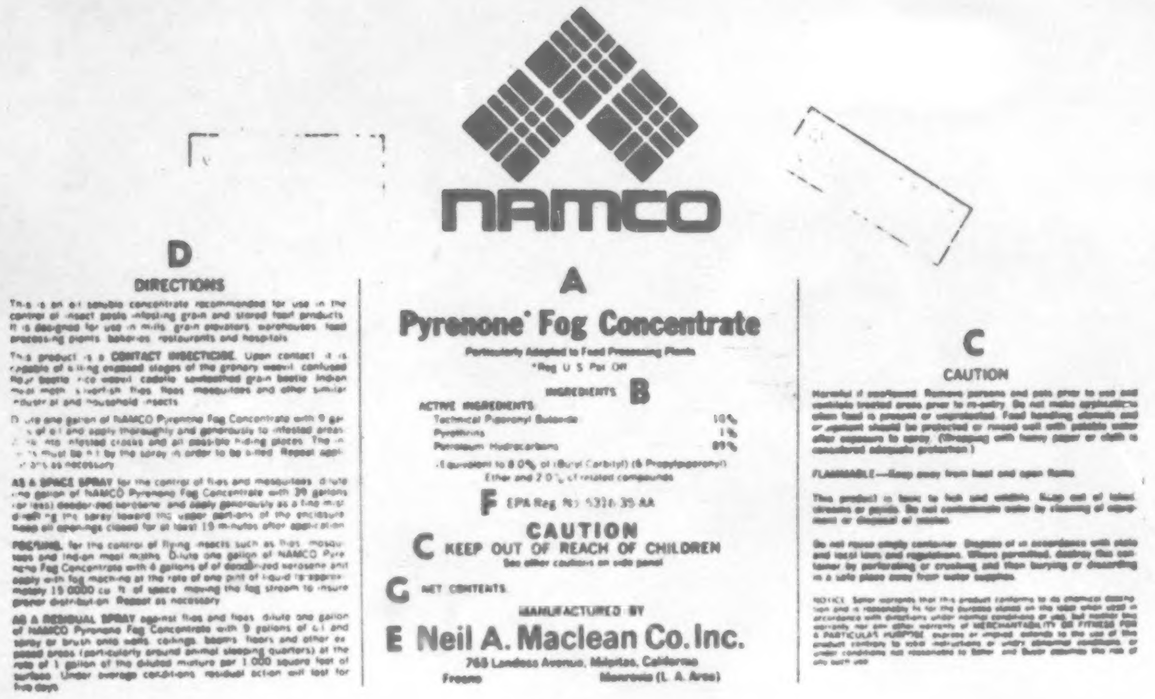

namco
D
DIRECTIONS
A
Pyrenone* Fog Concentrate
Particularly Adapted to Food Processing Plants
*Reg U S Pat Off
INGREDIENTS
B
ACTIVE INGREDIENTS
Technical Piperonyl Butoxide 10%
Pyrethrins 1%
Petroleum Hydrocarbons 89%
(Equivalent to 8.0% of (Butyl Carbityl) (6-Propylpiperonyl) Ether and 2.0% of related compounds
F
EPA Reg No 5316-35-AA
CAUTION
C
KEEP OUT OF REACH OF CHILDREN
See other cautions on side panel
G
NET CONTENTS
MANUFACTURED BY
E
Neil A. Maclean Co. Inc.
763 Landess Avenue, Milpitas, California
Fresno
Monrovia (L. A. Area)
C
CAUTION
FLAMMABLE—Keep away from heat and open flame

Figure 72 –

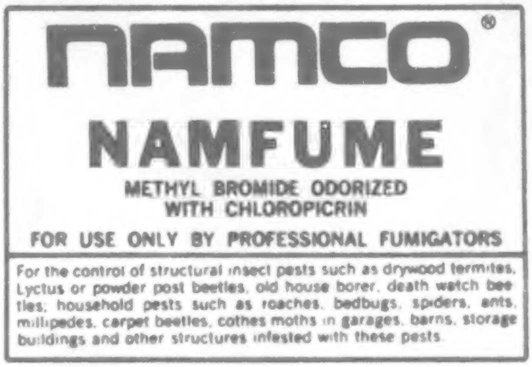
PARTS OF A LABEL

The pesticide label represents the best single source of information readily available to the user. It must contain: (Fig. 72).

1. Product name
2. Active and inert ingredients statement
3. Directions which are adequate for the safe, effective use of the product
4. Warning or caution statements to reflect the potential hazards due to ingestion, skin absorption, inhalation, flamability, and environmental contamination
5. Name and address of manufacturer or registrant
6. Net contents
7. E.P.A. registration number and establishment number
8. Appropriate preharvest or worker reentry intervals

PRODUCT NAME

Not only does it reflect the trade or brand name, but it will often have a summary of the uses for which the pesticide is intended. (Fig. 93). This will give the user an immediate idea as to its indicated uses, without going into the expanded directions for use. Certain types of formulations may be indicated by the use of initials (i.e., EC -Emulsifiable concentrate, WP - Wettable powder).



namco®

NAMFUME

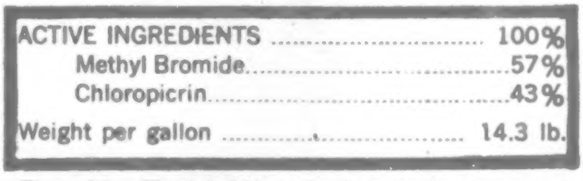
METHYL BROMIDE ODORIZED
WITH CHLOROPICRIN

FOR USE ONLY BY PROFESSIONAL FUMIGATORS

For the control of structural insect pests such as drywood termites, Lyctus or powder post beetles, old house borer, death watch beetles; household pests such as roaches, bedbugs, spiders, ants, millipedes, carpet beetles, cothes moths in garages, barns, storage buildings and other structures infested with these pests.

Figure 73 – The Product Name, Shown Here as "NAMFUME"

ACTIVE INGREDIENT



ACTIVE INGREDIENTS	100%
Methyl Bromide	57%
Chloropicrin	43%
Weight per gallon	14.3 lb.

Figure 74 – The Label Must Also Include the Amount of Active Ingredient by Weight

That is, the total amount of toxic material in the formulation, shown in (Fig. 74) as Methyl Bromide 57%, Chloropierin 43%.

SIGNAL WORD

WARNING
KEEP OUT OF REACH OF CHILDREN
See other warnings on side panel.

Figure 75 -- Signal Words Must be on Each Lebel

There are signal words on pesticide labels that are an indication of the degree of toxicity. A knowledge of the meaning of the signal words and symbols forewarns the pesticide user of potential hazards associated with the chemicals. (See section on signal words.)

Unqualified claims for safety are not acceptable on any label and all labels must bear the statement, "KEEP OUT OF THE REACH OF CHILDREN." (Fig. 75).

DIRECTIONS FOR USE

DIRECTIONS

COCKROACH CONTROL: For cleanout, mix 5⅓ ounces of NAMCO DURSBAN* 1-E per gallon of water (.5%). Use 2⅔ ounces per gallon (.25%) for light infestations or maintenance. Apply as a coarse spray or with a paint brush to areas where roaches are usually found. Repeat as needed. NOTE: A period of 4 to 7 days after treatment is normally required for maximum effect on roaches.

EARWIGS, CRICKETS, SOWBUGS AND PILLBUGS: Mix ⅜ to 3 ounces in 30 gallons of water and apply where these pests congregate such as cracks and crevices, around foundations and fence posts, under decaying matter or debris.

FLEAS AND TICKS: Indoors, use 2⅔ ounces per gallon of water. Spray cracks, crevices, along baseboards, floors and walks. Treat sleeping quarters of pets thoroughly.

OUTDOORS: Dilute 3 ounces in 30 gallons of water to cover 1,000 square feet of lawn area. Apply uniformly over area for complete coverage.

NOTE: Do not allow pets to contact treated areas until completely dry.

FLIES: Dilute 5⅓ ounces per gallon of water and apply as a coarse spray to surfaces such as walls and ceilings, around garbage areas, around doorways and animal shelters. Obtain complete coverage of treated surfaces.

CLOVER MITES: Mix 1.5 ounces per 30 gallons of water to cover 1,000 square feet. Apply to lawn areas, shrubbery and to outside walls up to window sills.

LAWN MOTHS, CUTWORMS: Mix 3 ounces per 30 gallons of water to cover 1,000 square feet. Make treatment when insects first appear and repeat as needed. Lawn should be moist at time of application.

Figure 76 – Labels Must Have Adequate Directions For Use of the Product

Directions include the names of crops, insects of diseases on which the product may be used. Methods of application and recommended dosage rates are also given. This part of the label should always be read before using the product.

NAME, ADDRESS, ETC. AND REGISTRATION NUMBER

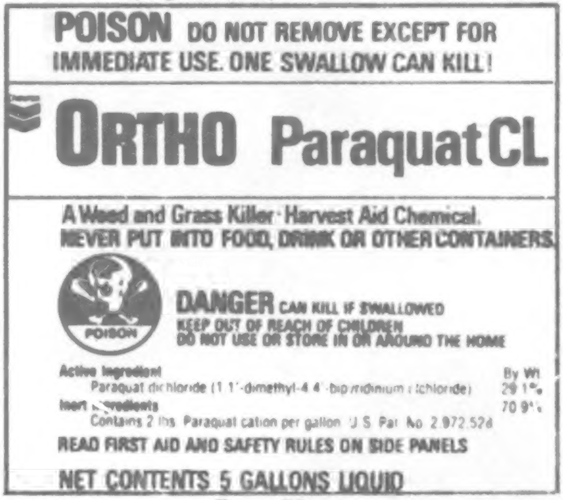
EPA Reg. No. 5316-42-AA State Reg. No. 05316-50012
NET CONTENTS:
MANUFACTURED BY
Neil A. Maclean Co. Inc.
765 Landess Avenue, Milpitas, California
Fresno Monrovia (L. A. Area)

Figure 77 – Labels Must Include the Name and Address of the Registrant or Manufacturer

This information is shown in (Fig. 77) as "Neil A. Maclean Co., Inc., Milpitas, Ca. In addition to the name and address, the assigned registration number must also be on the label. These 3 things, the product name, the manufacturer's name and the registration number must be known when an illness occurs. This information is vital and should be given to a physician or other person who requests accurate information about a pesticide.

NET CONTENTS

The net weight or measurement of content shall be exclusive of wrappers or other materials and shall be the average content unless explicitly stated as a minimum quantity. If the produce is a liquid, the net content shall be in terms of liquid measure and shall be expressed in conventional American units of fluid ounces, pints, quarts and gallons. (Fig. 77a). If the product is a solid viscous, or a mixture of solid and liquid, the net content statement shall be expressed as avoirdupois pounds and ounces. In all cases, net content shall be stated in terms of the largest suitable units, i.e., "2 pounds" rather than "32 ounces." (Figure 77b).



POISON DO NOT REMOVE EXCEPT FOR IMMEDIATE USE. ONE SWALLOW CAN KILL!

ORTHO Paraquat CL

A Weed and Grass Killer · Harvest Aid Chemical.
NEVER PUT INTO FOOD, DRINK OR OTHER CONTAINERS.

DANGER CAN KILL IF SWALLOWED
KEEP OUT OF REACH OF CHILDREN
DO NOT USE OR STORE IN OR AROUND THE HOME

Active Ingredient	By Wt
Paraquat dichloride (1,1'-dimethyl-4,4'-bipyridinium dichloride)	29.1%
Inert Ingredients	70.9%

Contains 2 lbs. Paraquat cation per gallon. U.S. Pat. No. 2,972,528

READ FIRST AID AND SAFETY RULES ON SIDE PANELS

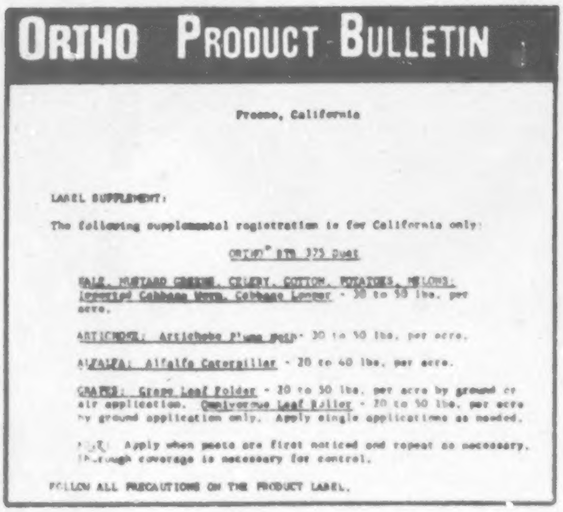
NET CONTENTS 5 GALLONS LIQUID

Figure 77a

GOLD CREST.
C-10%G
GRANULES
INSECTICIDE FOR USE ONLY BY PROFESSIONAL APPLICATORS

Figure 77b

PRODUCT BULLETIN



ORTHO PRODUCT BULLETIN

Fresno, California

LABEL SUPPLEMENT:

The following supplemental registration is for California only:

ORTHO® [illegible] 375 Dust

KALE, MUSTARD GREENS, CELERY, COTTON, POTATOES, MELONS: Imported Cabbage Worm, Cabbage Looper - 30 to 50 lbs. per acre.

ARTICHOKE: Artichoke Plume Moth - 30 to 50 lbs. per acre.

ALFALFA: Alfalfa Caterpillar - 20 to 40 lbs. per acre.

GRAPES: Grape Leaf Folder - 20 to 50 lbs. per acre by ground or air application. Omnivorous Leaf Roller - 20 to 50 lbs. per acre by ground application only. Apply single applications as needed.

NOTE: Apply when pests are first noticed and repeat as necessary. Thorough coverage is necessary for control.

FOLLOW ALL PRECAUTIONS ON THE PRODUCT LABEL.

Figure 78 – A Pesticide Registrant May Amend Labeling on His Products to Include Additional Usages, Dosage Modifications or Other Changes at Any Time

These labeling changes are commonly distributed as "Product Bulletins." If a usage recommended which is in the form of a product bulletin and not yet printed on the label itself, the product bulletin must be provided with the pesticide so the user will have all necessary use instructions and precautions. The applicator must have the labeling that corresponds with the usage or he will be in violation and may lose his license or permit. (Fig. 78).

NOTE TO PHYSICIAN

WARNING

May be fatal if swallowed. Combustible liquid. May be absorbed through skin. Do not get in eyes or on skin. Do not wear contaminated clothing. Wash thoroughly after handling. Avoid breathing spray particles. Handle concentrate in ventilated area. Keep away from food, feedstuffs and water supplies. Do not let children or pets contact treated area until thoroughly dry. Flush contaminated eyes and skin with plenty of water and for eyes get medical attention. Do not use in animal buildings, poultry houses or the edible product areas of food processing plants.

SEND FOR DOCTOR IMMEDIATELY IN CASE OF POISONING

FIRST AID: Place patient in fresh air, face downward, with head slightly below level of lungs. Keep warm. Give artificial respiration if breathing has stopped. Oxygen inhalation and stimulants of caffeine at doctor's discretion.

Note to Physician: DURSBAN insecticide is a Cholinesterase inhibitor. Treat symptomatically. Atropine is antidote.

Figure 79 – A Note to the Physician is Included on Labels

The label on the pesticide will give the physician needed information on the chemical involved so that he may accurately treat the victim. It will also allow the physician to accurately identify the pesticide if he must call a poison control center for additional information. (Fig. 79).

FIRST AID TREATMENT

IF SWALLOWED
Immediately induce vomiting by inserting finger in throat. Administer fluids and induce further vomiting. Get to a hospital or physician fast.
PROMPT TREATMENT IS ESSENTIAL. Symptoms of injury may be delayed.

SKIN CONTAMINATION
In case of contact, wash immediately with water. Remove clothing and wash skin where necessary. Prolonged contact will cause severe irritation. Repeated contact may increase danger of absorption.

EYE CONTAMINATION
In case of contact, wash thoroughly with water and get medical attention.

INHALATION
Do not breathe spray mist.
Exposure to spray mist may cause irritation and nose bleeds. Stop and check spray procedure.

Note to Physicians: Emergency Information-Call (415) 233-3737

FIG 79a

First aid information may also be included. Know where this is on the label of the material you use. If you need it, you will immediately know where to look. (Fig. 79a).

GENERAL AND RESTRICTED USE CATEGORIES

When a pesticide is first proposed for marketing, a request for registration is made to state and federal agencies. The manufacturer submits extensive information based on tests to establish the effectiveness of the product against particular pests. Information with the regard to comparative toxicity and any hazard involved in the use of the product is also sumbitted. A hazard may include possible injury to people, wildlife, the environment and watersheds. Consideration is also given to hazards that might arise if the material drifts onto adjacent crops.

In 1972, Congress recognized that despite extensive labeling and use instructions, pesticides were being misused on a large scale with serious effects on man and the environment. Congress amended the FIFRA to add key regulatory mechanisms. Among other things, they required that pesticides be classified for "general" and "restricted" use and provided that pesticides in the "restricted" category may be used only by, or under the direct supervision of certified applicators or under such other restrictions as EPA may require. The placement of a pesticide into either category is based on the data obtained in the toxicity and hazard studies previously mentioned. By October 1976, all registered pesticides must be classified for either general or restricted use.

A general use pesticide is defined as one which will not generally cause unreasonable adverse effects on the environment when used in commonly recognized practices in accordance with its labeling. Such pesticides normally will be available to the public. A restricted use pesticide is defined as one which may generally cause unreasonable adverse effects on the environment, including injury to the applicator, unless it is subject to additional regulatory restrictions beyond labeling. It should be noted that all restricted use pesticides will not necessarily be available to all certified applicators. Some pesticides will be limited to certain categories of commercial applicators. After certification goes into effect, it is possible that some product, uses, and formulations will be available only to commercial applicators with a particular specialized competence. If there is any doubt as to the use of a particular pesticide and its category, the label will clearly state this information.

CONFLICT OF USAGE AND LABEL RECOMMENDATIONS

No pesticide may legally be used or recommended in any form that is conflict with the recommendations on the registered label. "Conflict" includes uses or recommendations that:

1. Increase the rate of application over the maximum shown on the labeling.
2. Change the method, time of application, or other conditions of use shown on the label.
3. Include a crop to be treated or a pest to be controlled that is not shown on the label.

SIGNAL WORDS

There are 4 general categories of pesticides based on toxicity. The signal words are an indication of the degree of toxicity. A knowledge of the meaning of the signal words and symbols forewarns the pesticide user of potential hazards associated with the chemicals. It should be emphasized that these are only categories and there is considerable variation in the toxicity of the various pesticides that fall in each group. A wise operator will know the exact toxicity of each chemical he handles.

——☠ POISON ☠——

DANGER

Figure 80 – The Signal Words "DANGER," "POISON," and a Skull and Crossbones

This symbol is required on labels for all highly toxic compounds. A taste to 1 teaspoon is probably the acute oral lethal dose of these chemicals to the average man. Under worker safety provisions, in some states, these would be classed as "Category 1 Pesticides." (Fig. 80).

WARNING: KEEP OUT OF REACH OF CHILDREN!

Figure 81 – Signal Word "WARNING"

Pesticides in toxicity category 2 will show prominently on their labels the signal word "WARNING." (Fig. 81). These are moderately toxic pesticides. For the layman, 1 to 2 tablespoonsful is the probably acute oral letal dose.

CAUTION

KEEP OUT OF REACH OF CHILDREN

See other cautions on side panel

Figure 82 – Signal Word "CAUTION"

Pesticides in toxicity category 3 will show prominently on their labels the signal word "CAUTION." (Fig. 82). These are the slightly toxic pesticides. One ounce to 1 pint if consumed over a short period of time would probably kill the average man.

KEEP OUT OF REACH OF CHILDREN!

Figure 83 – Keep Out of the Reach of Children

No special signal words or symbols are required on labels for compounds that have an acute oral lethal range from 1 pint to 1 quart or more. However, unqualified claims for safety are not acceptable on any labels and all labels must bear the statement "KEEP OUT OF REACH OF CHILDREN." (Fig. 83).

WHEN THE OPERATOR SHOULD READ THE LABEL

1. Before purchasing the chemical, read the label to determine:
    a. If this is the chemical needed for the job.
    b. Never purchase or select a pesticide based on the color of the label. Labels of the same color and general make-up may contain widely different active ingredients.
    c. If a material is too toxic or hazardous to be used safely under the prevailing conditions.
    d. The concentration in percent or pounds per gallon of active ingredient.
    e. If this formulation is suitable for equipment to be used.
2. Before mixing the material, read the directions to determine:
    a. Is protective equipment necessary when handling the pesticide.
    b. Warnings and antidotes.
    c. What the pesticide can be mixed with (compatibility).
    d. How to mix the pesticide.
    e. How much to use.
3. Before applying, read the directions to determine:
    a. Safety measures necessary for applicator.
    b. To what it can be applied.
    c. When to apply (including waiting period on crops and animals).
    d. How to apply.
    e. Rate of application.
    f. Restrictions of use.
    g. Special instructions.
4. Before storing or disposing of the pesticide containers, read the directions to determine:
    a. Where and how to store.
    b. Where it should not be stored.
    c. What it should not be stored with.
    d. How to decontaminate and dispose of the container.
    e. Where to dispose of leftover pesticides or their containers.

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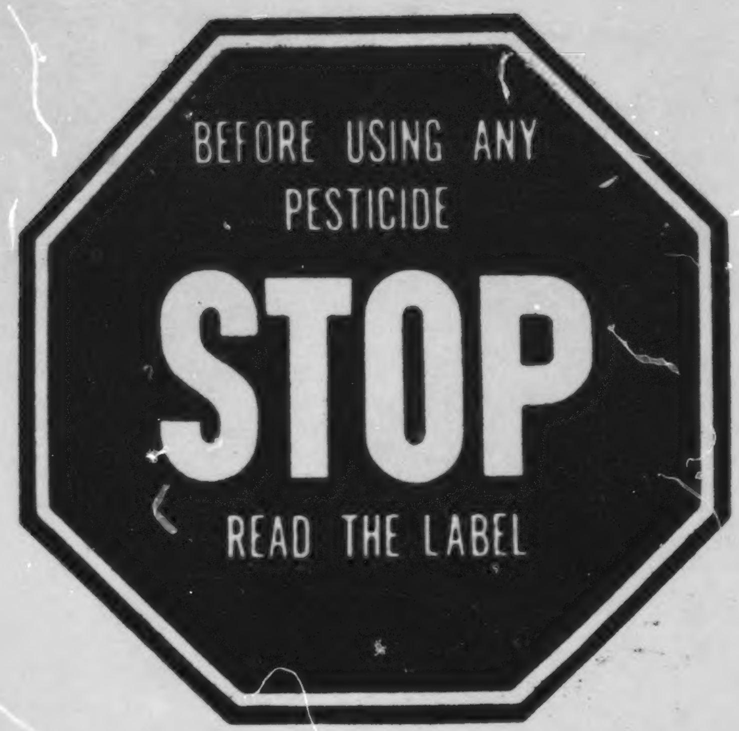
U.S. Environmental Protection Agency. 1974. Certification of pesticide applicators.


BEFORE USING ANY PESTICIDE
STOP
READ THE LABEL

LEARNING AT HOME

Review Questions – Section 4

1. When reading a label, there are 4 important things to the applicator. Name them:
   a. ________________
   b. ________________.
   c. ________________.
   d. ________________.
2. What 2 numbers must appear on a label: ____________.
3. What statement must appear on all labels, regardless of whether the contents are in category one, two or three ____________.
4. What 2 signal words must appear on a category one label ____________.
5. The signal words on labels are an indication of the degree of____________.
6. Name 3 reasons for reading the label before purchasing the pesticide:
   a. ________________.
   b. ________________.
   c. ________________.
7. Name 5 reasons for reading the label before applying:
   a. ________________.
   b. ________________.
   c. ________________.
   d. ________________.
   e. ________________.
8. Name 5 reasons for reading the label before storing or disposing of containers:
   a. ________________.
   b. ________________.
   c. ________________.
   d. ________________.
   e. ________________.
9. Name 5 reasons for reading the label before mixing the material:
   a. ________________.
   b ________________
   c. ________________
   d. ________________.
   e. ________________

OUTSIDE ASSIGNMENTS

1. Obtain several sample labels of the pesticides commonly used in your area. Study them and type a list of all the important items of interest to you under separate heading of each formulation.
2. Reproduce labels of interest and make them a part of your note book.

PESTICIDE SAFETY

Henry G. Schierenberg
Agricultural Biologist,
Calif. State Dept. of Agriculture

Pesticides can be effective and safe tools when used properly. However, if misused, they can be harmful to man, animals and the environment. The following discussions will cover more important points concerning pesticide safety and First Aid.

TOXICITY

Toxicity values alone should not be the only factor considered regarding the toxic effect of a chemical on humans or other animals. Anyone who handles pesticides should be concerned with the hazard associated with the exposure to the chemical. The terms toxicity and hazard are not synonymous. **TOXICITY** is the inherent capacity of a substance to produce injury or death. **HAZARD** is a function of 2 primary variables, toxicity and exposure and is defined as the probability that injury will result from the use of a substance in a given formulation, quantity, or manner. Some hazards do not involve toxicity to humans, or other animals. For example, sulfur, oils and numerous other chemicals are considered safe or relatively safe to animals but may pose considerable hazards to some plants (phytotoxicity).

A compound may be extremely toxic but present little hazard to the applicator or others when used:

1. In a very dilute formulation.
2. In a formulation that is not readily absorbed through the skin or readily inhaled.
3. Only occasionally and under conditions to which humans are not exposed.
4. Only by experienced applicators who are properly equipped to handle the chemical safely.

Or, a chemical may exhibit a relatively low mammlian toxicity but present a hazard because it:

1. Is normally used in the concentrated form.
2. Is readily absorbed or inhaled.
3. May be used frequently by the nonprofessional home gardeners, etc., who are not award of the possible hazards to which they are being exposed.

Toxicity values can be expressed as an acute oral or acute dermal LD50 in terms of milligrams of the toxicant per kilogram (mg/kg) of body weight of the test animal; or in inhalation data as LC50 in terms of micrograms of mist or dust per liter of air (ug/1) or parts per million by volume of gas or vapor (ppm).

LD means lethal dose and LD50 means lethal dose that will kill 50% of a large population of test animals. LC means lethal concentration and LC50 means lethal concentration that will kill 50% of the test animals.

Acute oral refers to a single dose taken by mouth or ingested. Acute dermal refers to a single dose applied directly to the skin (skin absorption). Inhalation refers to exposure through breathing or inhaling.

Thus if a toxicant were said to have an acute oral LD50 of 10, this would mean that if 10 milligrams of this material were fed to each of 100, 1 kilogram rats through the mouth at one feeding, on the average 50 of the rats would die. Estimated relative acute toxic hazards of pesticides to spraymen are given in Table 12.

HOW PESTICIDES ENTER THE BODY

There are 3 common routes through which a pesticide can enter the body:

1. Absorption through the skin (dermal). Conjunctival or penetration through the eyes is a special category of dermal.
2. Absorption through the gastrointestinal tract (oral).
3. Absorption through the lungs (inhalation).

Dermal

This is reportedly the most common route of pesticide exposure (Fig. 84). Generally a dermal exposure can result:

1. From accidentally spilling or spraying a pesticide directly on the skin.
2. By wearing clothing on which a pesticide has been spilled.
3. By drift of pesticides applied under windy conditions.

Figure 84 Pesticide Poisoning by Skin Contact is the Most Common Method of Exposure

TABLE 12 - ESTIMATED RELATIVE ACUTE TOXIC HAZARDS OF PESTICIDES TO SPRAYMEN[*]

The estimates of hazards in this table are based primarily on the *observed acute dermal* and to a less extent oral toxicity of these compounds to experimental animals. *Where it is available, use experience has also been considered.* It should be noted that the classification into *toxicity groups* is *both approximate and relative.* These toxicity categories are not related to specific categories spelled out for label requirements.

Most Dangerous	*Dangerous*	*Less Dangerous*[†]	*Least Dangerous*
carbanolate, Temik (M)[‡]	aldrin (CH)	azinphosmethyl, Guthion® (OP)	Aramite® (M)
demeton, Systox® (OP)	Bidrin® (OP)	BHC (CH)	captan (M)
disulfoton, Di-Syston® (OP)	carbophenothion, Trithion® (OP)	binapacryl, Morocide® (N)	carbaryl, Sevin® (C)
mevinphos, Phosdrin® (OP)	DDVP, dichlorvos (OP)	chlordane (CH)	chlorobenzilate (CH)
parathion (OP)	dieldrin (CH)	coumaphos, Co-Ral® (OP)	2,4-D (CH)
phorate, Thimet® (OP)	dioxathion, Delnav® (OP)	diazinon (OP)	DDD, TDE (CH)
schradan, OMPA (OP)	DNOC (N)	dicapthon (OP)	DDT (CH)
tepp (OP)	DNOSBP (N)	dichloroethyl ether (M)	dicofol, Kelthane® (CH)
thionazin, Zinophos® (OP)	endrin (CH)	dimethoate, Cygon® (OP)	Dilan® (CH,N)
	EPN (OP)	endosulfan, Thiodan® (CH)	dinocap, Karathane® (N)
	ethion, Nialate® (OP)	fenthion, Baytex® (OP)	diquat (M)
	methyl parathion (OP)	heptachlor (CH)	IPC, propham (M)
	nicotine (M)	lead arsenate (M)	malathion (OP)
	pentachlorophenol (M)	lindane (CH)	maneb (M)
	phosphamidon, Dimecron® (OP)	naled, Dibrom® (OP)	methoxychlor (CH)
	sodium arsenite (M)	oxydemetonmethyl, Meta-Systox®-R (OP)	mirex (CH)
	Zectran® (C)	Ruelene® (OP)	Morestan® (M)
		SMDC, Vapam® (M)	NAA (M)
		trichlorfon, Dipterex®, Dylox® (OP)	Perthane® (CH)
		toxaphene (CH)	piperonyl butoxide (M)
		VC-13 (OP)	ronnel, Korlan® (OP)
			rotenone (M)
			simazine (M)
			2,4,5-T (CH)
			tetradifon, Tedion® (CH)
			thiram (M)
			zineb (M)
			ziram (M)

[*] Source of Data: Safety in the Use of Pesticides, Homer R. Wolfe, William F. Durham. Proc. 2nd Eastern Wash. Fertilizer and Pesticide Conf. Pullman; Washington State University, pp. 14-21, 1966.

[†] The fumigant compounds acrylonitrile D-D® and Telone® have systemic toxicities which would indicate their placement under the "Less Dangerous" category. However, special note should be taken of the fact that the volatility of these compounds and their capacity to produce irritation of skin, eyes and other tissues indicate that appropriate caution should be exercised in their use.

[‡] The chemical class to which the pesticide belongs is designated as follows: C, carbamate; CH, chlorinated hydrocarbon; M, miscellaneous; N, nitro; and OP, organic phosphorus.

Oral

This type of exposure results from accidentally getting a pesticide in your mouth (Fig. 85). To minimize the chance of this happening, an operator who has been working with toxicants should wash thoroughly before eating or drinking. Lunch, beverages or other eatables should not be needlessly exposed to pesticides. To avoid the accidental drinking of a pesticide by children, do not store pesticides in anything (such as soft drink bottles) other than their original container (Fig. 86).

Inhalation

Vapors and very fine particles represent the most serious potential of inhalation exposure. Respirators offer protection against inhaling chemicals and should be worn when handling or applying the more toxic organophosphate or carbamate pesticides (Fig. 87). The label will indicate if a respirator is necessary.

Figure 85 Pesticides are Most Toxic When Consumed

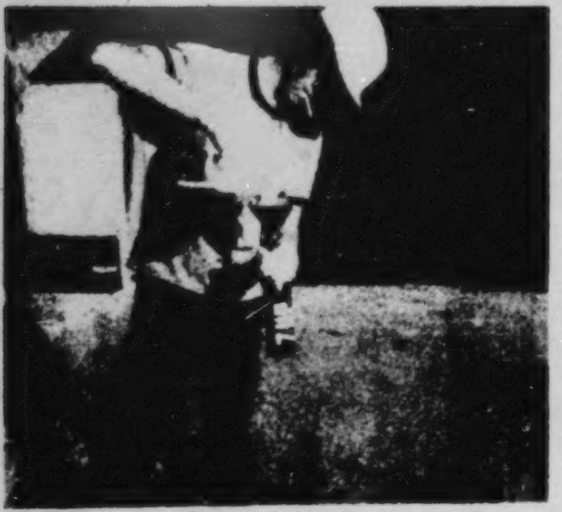


Figure 86 – Even Temporary Storage of Pesticide in Food or Drink Containers is Potentially Very Dangerous

Figure 87 – A Respirator Should Be Worn When There Is a Potential of Inhaling Sprays of the More Toxic Insecticides

In general, wettable powders, dusts and granular pesticides are not as readily absorbed through the skin and other body tissues as are the liquid formulations such as emulsifiable concentrates. Emulsifiable concentrates contain a high percentage of the toxicant in a relatively small amount of solvent. The solvents are readily absorbed through the skin. Anyone who may be exposed to repeated and/or prolonged contact with pesticide should take all necessary precautions to avoid personal contamination by wearing protective clothing and safety devices as prescribed by the manufacturer, and should follow recommended procedures for mixing and applying these chemicals.

HOW PESTICIDES AFFECT HUMANS AND RECOGNITION OF THESE EFFECTS

IMPORTANT

The information in this section may help to save a life, yours or your friend's. Even if this manual is close by when an accident occurs, there may not be time to find and read this section or the one on First Aid. This information should be in your head, not just in the manual.

Even though it may not be exactly known how all pesticide poisons the body, some of the signs and symptoms resulting from such poisoning are quite well known. These warnings (signs and symptoms) of the body in response to poisoning should be recognized by those who use pesticides.

Everyone is subject to various sicknesses, or diseases. Therefore, it cannot be assumed that because an individual is in the vicinity where pesticides are or have been used that certain signs or symptoms are the result of pesticide poisoning. But if any signs or symptoms do appear after possible contact with pesticides (Fig. 88), a physician should be contacted and advised of the nature of the problem. The operator should be alert to the early stages of signs and symptoms of poisoning and if they do occur, he should immediately and completely remove the source of exposure (chemical), such as contaminated clothing. By so doing, the operator may prevent additional exposure and minimize injury. In some instances, early recognition of these warnings and immediate and complete removal of the source of exposure may save a life.

NOTE: The symptoms and signs described here may occur in a person who has been suddenly exposed to lethal quantities of a toxic material. Or they may occur in a person who has been continuously exposed to smaller quantities of toxic material over an extended period of time. In either case, the same emergency procedure should be followed. (See the sections on: First Aid and Use of Antidotes).

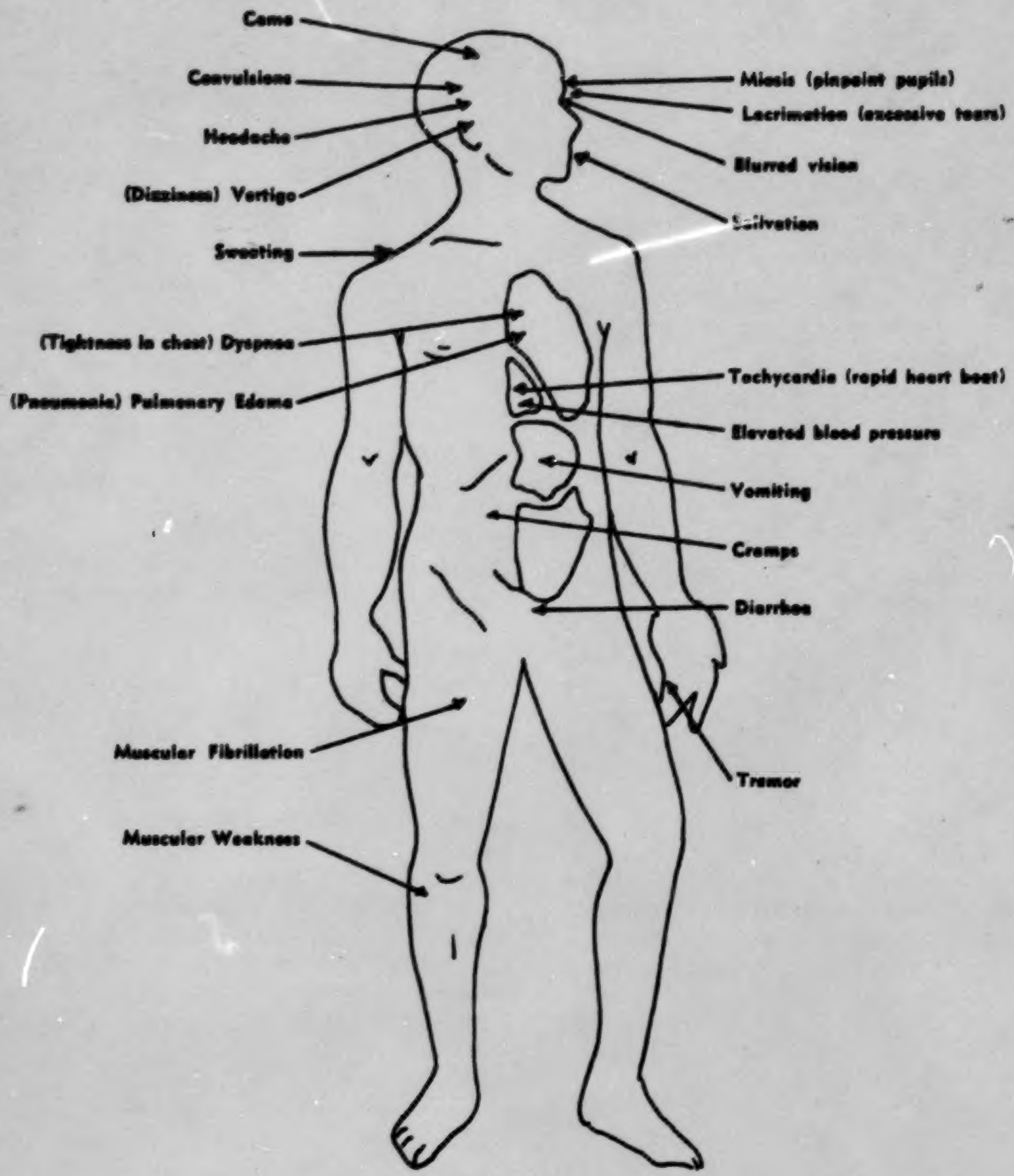

Coma
Convulsions
Headache
(Dizziness) Vertigo
Sweating
(Tightness in chest) Dyspnea
(Pneumonia) Pulmonary Edema
Muscular Fibrillation
Muscular Weakness
Miosis (pinpoint pupils)
Lacrimation (excessive tears)
Blurred vision
Salivation
Tachycardia (rapid heart beat)
Elevated blood pressure
Vomiting
Cramps
Diarrhea
Tremor

Figure 88 Symptoms of Pesticide Poisoning

SIGNS AND SYMPTOMS

Organophosphorus and Carbamate Pesticides

Examples are TEPP, demeton (systox) parathion, (Phosdrin), Bidrin. These pesticides attach themselves to a chemical that is normally present and necessary for proper nerve function. This chemical is an enzyme known as cholinesterase. Since the action of the organophosphorus pesticides "ties up" the enzyme cholinesterase, they are referred to as cholinesterase inhibitors or anti-cholinesterase compounds.

When cholinesterase is tied up and unable to perform its normal function, the nerves in the body continue to send messages to certain muscles which make them move constantly. These constant muscle twitchings and weaknesses are referred to as tremors or fibrillations. If this muscle action becomes intense, the victim may have fits or uncontrolled convulsions which are simply uncontrolled violent muscle actions.

In mild cases of poisoning from these chemicals, symptoms may include headache, weakness, perspiration, nausea, nervousness and fatigue. More advanced symptoms usually associated with more severe cases of poisoning are excessive salivation, lack of muscle coordination, muscle twitching, excessive perspiration, and blurred vision. The most advanced symptoms are intense thirst, rapid breathing, vomiting, uncontrolled muscle twitching, pinpoint pupils, convulsion and unconsciousness. These last 4 signs are typically seen in advanced or severe cases of poisoning. Even though the patient may be near death at this stage of poisoning, he may be saved if the proper medical treatment is obtained quickly and continued for a long enough period of time. Although always present in advanced stages, pinpoint or constricted pupils may be seen in any stage of poisoning and is a diagnostic characteristic of organophosphorus or carbamate poisoning.

Chlorinated Hydrocarbon Insecticides

These compounds act on the central nervous system, but the exact mode of action is not known. Large doses cause diarrhea and vomiting. Repeated large doses can cause liver and kidney damage in animals, but these signs have not been demonstrated in man. Nervousness and convulsions may occur in some instances.

Nitrophenol Pesticides (Wood Treating Compounds)

Poisoning from these compounds may result in fever, sweating, rapid breathing, rapid heartbeat and unconsciousness. (In cases of single, large exposures, these symptoms may occur rapidly. Death may occur within 24 to 48 hours.) Chronic or extended cases may exhibit nervousness, sweating, unusual thirst and loss of weight.

Arsenic (Rodenticide)

The arsenic compounds tend to precipitate protein. Poisoning from these compounds may lead to stomach and intestinal pain, vomiting, diarrhea, severe drop in blood pressure, dizziness and difficulty in walking.

Sodium Fluoroacetate (Rodenticide -- Compound 1080)

The mode of action of this chemical is poorly understood. It affects the heart and nervous system in most animals and certain muscles in some species.

Botanical (Plant Derivatives)

Botanical insecticides vary greatly in their chemical structure as well as their toxicity to man. Their toxicity range from pyrethrum, a slightly toxic insecticide to strychnine which is extremely toxic. In minor cases injury to man from pyrethrum usually results in skin allergies, sneezing, runny nose and in some instances, stuffiness of the nose. Usually such signs and symptoms are of a mild nature. However, some people are sensitive to pyrethrum.

Strychnine is known to act on the nervous system causing extreme nervousness in some instances. Sometimes the muscles of the face and legs become stiff. The patient may become extremely restless and have fits. Cold sweat covers the skin and the patient sometimes falls asleep from complete exhaustion. From 1 to 10 violent attacks may occur before the patient either recovers or death follows due to his inability to breathe. In the absence of effective medical treatment, most victims do not tolerate more than 5 convulsions and death commonly occurs within 3 to 5 hours after a fatal dose has been consumed. If the patient survives the first 5 to 6 hours, his chances for recovery are good.

Nicotine is very toxic and its action is very rapid. Nicotine works on the nervous system of the body. The usual signs and symptoms of nicotine poisoning are local skin burns and irritation. If nicotine is absorbed through the skin or if it is taken in through the mouth, the patient becomes highly stimulated and excitable. This is generally followed by an extremely depressed feeling. In fatal cases of nicotine poisoning, death is usually rapid, nearly always within one hour and occasionally within 5 minutes due to paralysis of respiratory muscles.

Anticoagulants (e.g., Warfarin)

There are 2 types of action from poisoning with the anticoagulants. One is an effect on the blood which reduces the body's ability to produce blood clots, and the other is damage to certain tissues that carry blood throughout various portions of the body. Both conditions lead to bleeding if any portion of the body is even slightly damaged. The beginning symptoms, in a case in which a human attempted suicide using warfarin, were stomach and intestinal pains. These occurred one day after the poison had been consumed in this suicide attempt. One day after the symptoms began to appear, vomiting and several attacks of nose bleeding occurred. On the second day of illness, small red patches appeared on the skin in the form of a rash. There was blood in this patient's urine. When laboratory tests were run on this individual's blood, it was found that it took much longer than usual for the blood to form clots. In another case massive bruises developed at the knee and elbow joints as well as on the person's buttocks. Extensive nose bleeding occurred about a day later.

Methyl Bromide

Methyl bromide is one of the most hazardous pesticides used today. The signs and symptoms produced by this compound are severe chemical burns of skin and other exposed tissue, delayed chemical pneumonia, accumulation of water in the lungs, severe kidney damage and extreme nervousness. In mild cases, there is an appearance of alcoholic intoxication, skin rashes, mental confusion, double vision, tremors, lack of coordination and the speech is slurred.

FIRST AID IN THE EVENT OF CHEMICAL POISONING

If you are alone with the victim –

First – See if victim is breathing; if not, give artificial respiration.

Second – Wash him off thoroughly. Speed is essential!

Third – Call your physician.

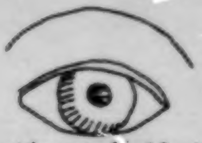
NOTE: Do not substitute First Aid for professional treatment. First Aid is only to relieve the patient before medical help is reached.

If another person is with you and the victim –

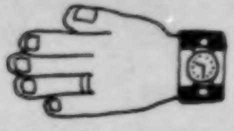
Speed is essential; one person should begin First Aid treatment while the other calls a physician.

The physician will give you instructions. Follow the physician's instructions.

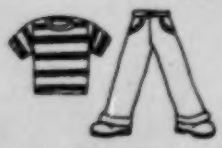
IN CASE OF ACCIDENTAL CONTACT



Flush with water for 15 minutes
Get medical attention immediately



Wash with soap and water



Wash with detergent before reusing

Always - Refer to product label for information. If contact is significant or person feels ill, take product label and get medical attention immediately.

EMERGENCY SUPPLIES

Keep the following minimum supplies readily available:
Rubber or Neoprene Gloves (2 pair)
Rubber or Neoprene Overshoes (1 pair)
Absorbent Material (1 large bag)
  —Zorb-All,® Kitty Litter,® etc.
Detergent (10 lb. or 2 qt.)
  —Strong household type, Tide,® All,® etc.
Disposable Pail (5-gal)

Disposable Plastic Bags (2)
  —Heavy-duty garden type
Broom (1)
  —Household type with natural bristles
Scoop Shovel (1)
Fire Extinguisher (10 lb.)
  —Rated for A, B, & C type fires

Figure 89 – What To Do In The Case Of An Accident

STEPS IN FIRST AID

General

1. Give mouth-to-mouth artificial respiration if breathing has stopped or is labored.
2. Stop exposure to the poison, and if poison is on skin, cleanse the person, including hair and fingernails. If swallowed, induce vomiting.
3. Save the pesticide container and material if any remains; obtain readable label or name of chemical(s) for the physician. If the poison is not known, save a sample of the vomitus.

Figure 90 – If a Toxicant Comes in Contact with the Skin, All Exposed Areas Should be Immediately Cleaned with Soap and Water

Figure 91 – Eyes Should be Rinsed with Water for 15 Minutes after Exposure to Toxicants

Specific

Poison to Skin

1. Drench skin and clothing with water (shower, hose, faucet)(Fig. 90).
2. Remove clothing.
3. Cleanse skin and hair thoroughly with soap and water.
4. Dry and wrap in blanket.

Poison in Eye

1. Hold eyelids open, wash eyes with gentle stream of clean running water immediately (Fig. 91). The eye will absorb material much faster than other exposed skin areas.
2. Continue washing for 15 minutes or more.
3. Do not use chemicals or drugs in wash water as they may increase the extent of injury.

Inhaled Poisons (Dusts, Vapors, Gases)

1. If victim is in enclosed space, do not go in after him without air-supplied respirator.
2. Carry patient (do not let him walk) to fresh air immediately.
3. Loosen all tight clothing.
4. Apply artifical respiration if breathing has stopped or is irregular.
5. Prevent chilling (wrap patient in blankets but don't overheat him and keep patient as quiet as possible).
6. Do not give alcohol in any form.
7. If patient is convulsing, watch his breathing and protect him from falling and striking his head on the floor or wall. Keep his chin up so his air passages will remain free for breathing.

Swallowed Poisons

If a pesticide has been swallowed, a decision must be made as to whether or not to induce vomiting. This decision depends on the condition of the victim and the nature of the substance swallowed. In either case, the victim should be given large amounts of water or milk to dilute and neutralize the poison.

Vomiting should NOT be induced if:

1. The victim is unconscious or in convulsions.
2. The victim has swallowed a corrosive poison (strong acid or alkali; symptoms are severe pain and burning in the mouth and throat).
3. The victim has swallowed petroleum products, such as gasoline or oil. Most pesticides which come in liquid formulations (e.g. emulsifiable concentrates) and are dissolved in petroleum products.

Vomiting SHOULD be induced if the patient is conscious and has swallowed a non-corrosive, non-petroleum poison. To induce vomiting, the patient should first be placed face down or kneeling forward. This will prevent vomitus from entering the lungs. Next, place a finger or a blunt object at the back of the throat. A glass of strong salt water will also cause the victim to vomit. Do not waste excessive time in inducing vomiting if the hospital is a long distance away. It is better to spend the time getting the patient to the hospital where drugs can be administered to induce vomiting and/or stomach pumps are available. Collect some of the vomitus in case physician needs it for chemical tests.

Chemical Burns of Skin

1. Wash with large quantities of running water.
2. Remove contaminated clothing.
3. Immediately cover with loosely applied clean cloths. Any kind will do, depending on the size of the area burned.
4. Avoid use of ointments, greases, powders, and other drugs in first aid treament of burns.
5. Treat shock by keeping patient flat, warm, and reassured until arrival of physician.

PESTICIDE SAFETY IN SPECIAL SITUATIONS

In addition to the basic rules which apply to everyone handling or applying pesticides, the following suggestions are given for specific types of operations.

Fumigators (Structures and Commodities)

1. Post property before you begin a fumigation.
2. Have available and use a fumigation safety kit, effective gas mask for fumigant to be used, and chart of instructions for artificial respiration.
3. Use adequate warning agent with all fumigants lacking such properties. For example, chloropicrin is used as a warning agent for methyl bromide.
4. Take all safety precautions necessary to protect the public during any hours and under any conditions where abnormal hazards exist.
5. Aerate fumigated goods and/or structures and test air before they are handled or entered.
6. Use proper detector equipment.
7. Supervise employees.

Greenhouse Operations

Applying pesticides in greenhouses presents special problems. In normal greenhouse operation, employees must work inside. Space is generally limited and personal contact with plants and other treated surfaces is almost a certainty. In addition, unauthorized persons may attempt to enter the premises. Ventilation in greenhouses is frequently kept to a minimum to maintain desired temperatures and as a result fumes, vapors, mists, and dusts may remain in the air for considerable periods of time and create hazards.

Pesticides applied to plants and other surfaces in greenhouses do not generally break down as rapidly as they do outside. This is due to a reduced amount of moving air and lack of rain to wash the chemicals off, dilute them or combine with them chemically to break them down further. In addition, the glass in the greenhouse filters out the ultraviolet light which would normally contribute to the degradation of certain chemicals.

1. Select chemicals that are most effective for pest control and present the least hazard to humans and animals.
2. When using toxic pesticide, especially fumigants, applicators should use gas masks and waterproof protective clothing. See the section in this manual on "Protective Clothing and Devices."
3. Post warning signs on the outside of all entrances to the house when fumigants or other highly toxic pesticides are being applied. Follow label instructions.
4. Do not enter the building without a gas mask or permit others to do so until it has been aired for the length of time recommended on the pesticide label.
5. All possible skin contact with treated plants and other surfaces should be avoided by workers and others to minimize skin irritation, sensitization, and absorption of chemicals through the skin. Where this is impossible, workers should wear clean, dry protective clothing and wash frequently.

Household

1. Select only material specifically labeled for use in the home'
2. Never deviate from the label directions. Keep pesticides out of the reach of children.
3. Cover or remove dishes, utensils, food containers and stored products before applying pesticides.
4. Do not apply sprays or aerosols around lighted fires or into electrical connections.
5. Do not use pesticide vaporizers in the home.

ANTIDOTES – THEIR USE BY NONMEDICAL PEOPLE

An antidote is a remedy used to counteract the effects of a poison or prevent or relieve poisoning. Therefore, good judgment and safety devices and knowledge of First Aid are in a sense antidotes since they can and frequently do prevent or relieve poisoning. However, the general public is inclined to think of antidotes almost exclusively in terms of special chemicals that must be purchased from a druggist or prescribed by a physician.

General Internal Antidotes

1. Clean water dilutes poison.
2. Salt water dilutes and may cause patient to vomit the poison.
3. Milk dilutes and helps counteract acid or a alkali poison.
4. Milk of Magnesia counteracts acid poisons. (Often available from home medicine chest).

Universal Antidote

Have a druggist mix 2 parts activated charcoal, 1 part magnesium oxide and 1 part tannic acid. The recommended dose is 1/2 ounce in 1/2 glass of warm water. This will absorb or neutralize poisons. Except after corrosive substances, the patient must be given an emetic (to cause vomiting) or his stomach must be pumped free of the poison. A homemade version of this universal antidote is 4 tablespoons of crumbled burnt toast (burned black), 2 tablespoons strong tea and 2 tablespoons Milk of Magnesia.

Specific Internal Antidotes Administered by, or Under the Direction of a Physician.

1. Vitamin K is used against anti-coagulants such as warfarin (rodenticide).
2. Bal (Dimercaprol) is a specific antidote for arsenic poisoning. This may be obtained from a druggist. It must be injected by a physician.
3. Atropine is used to counteract effects of cholinesterase inhibitors such as organophosphorus and carbamate pesticides. It is dangerous if misused and should be kept away from children.
4. Protopam chloride (2-PAM) is used to counteract effects of many organophosphorus pesticides. It has been most effective against parathion poisoning. This compound is frequently suggested for use in conjunction with atropine for organophosphorus poisoning. This chemical should not be used against diazinon or carbamatee pesticides.

PROTECTIVE CLOTHING AND OTHER SAFETY DEVICES

The use of protective clothing and other safety devices offers some protection against skin contact and/or inhalation of certain pesticides by the operator (Fig. 92), but it does not eliminate the necessity for other essential precautions. Coveralls, rainsuits, head and neck coverings, boots, gloves, goggles and respiratory devices are designed to protect the person who is handling or applying pesticides from direct contact with the material. Check the label of the pesticide container. If it calls for the use of certain pieces of protective equipment, wear them.

(Pesticides with labels marked: DANGER POISON. or WARNING)

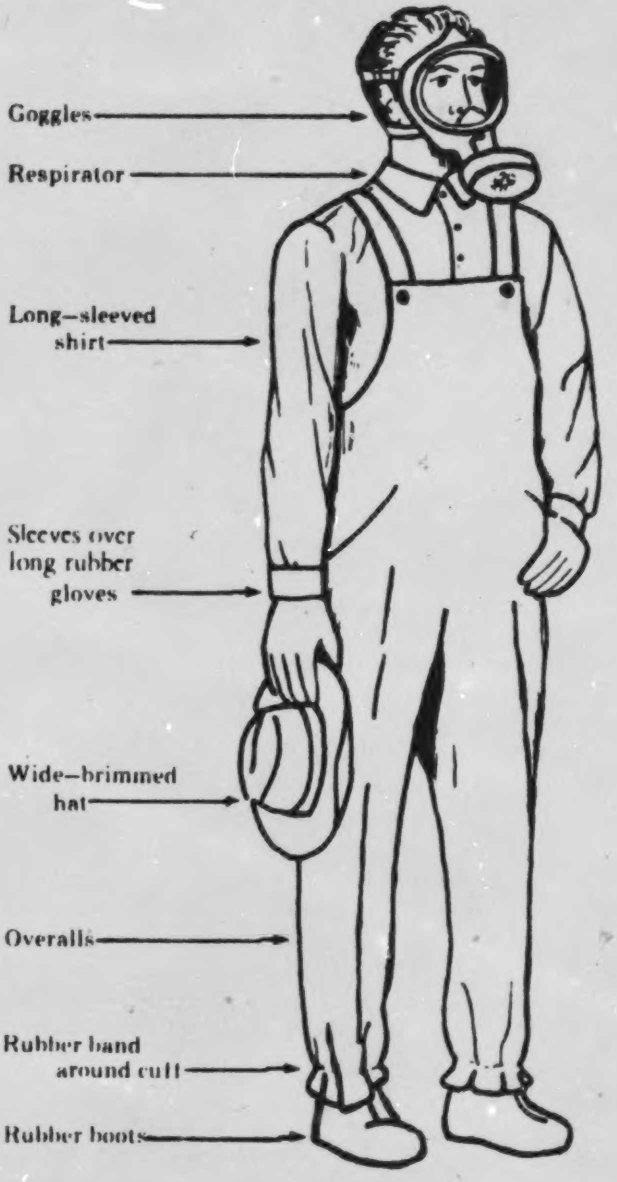


Figure 92 – Protective Clothing for Hazardous Pesticides

Gloves

Wear natural rubber gloves when handling organophosphorus or carbamate insecticides unless another type is suggested by the pesticide manufacturer. Always check gloves very carefully for tiny (pinpoint) holes. Fill the gloves with water and squeeze; if water comes out, discard them. For other pesticides, follow the manufacturer's suggestion. Never use leather or cotton gloves when handling or applying pesticides. Leather or cotton will absorb the toxicant and provide a constant exposure to the chemical. These types of gloves and those with holes are potentially a greater hazard than if no gloves are worn.

Coveralls or Waterproof Rainsuits

To reduce skin contamination, wear clean coveralls that cover the entire body. If outer garments will be wet from mist, spray or spillage, wear a waterproof rainsuit. They should be washed after each use with soap and water.

Head and Neck Coverings

Protect the hair and skin about the head and neck from contact with pesticides by using waterproof rainhats, safety hard hats and caps. Waterproof or repellent parkas may be used. Do not wear old felt hats or other absorbent types of headgear. These will absorb pesticides, especially in the sweatband and provide a continuous exposure.

Boots

Wear only rubberized boots when handling or spraying on a large scale. Leather and canvas absorb chemicals and will hold them in contact with the wearer. Boots should be washed and thoroughly dried as frequently as needed to remove any contaminant.

Goggles

Good, effective, nonfogging goggles are readily available and should be worn when there is any chance of a chemical coming in contact with the eyes, especially when pouring or mixing concentrates, as well as when spray or dust drift may be encountered. Keep goggles clean at all times, especially the headband which may be of an absorbent material and is in contact with the head.

Respiratory Devices

The 3 kinds of respiratory protective devices in general use are chemical cartridge respirators (Fig. 93), gas masks (Fig. 94), and supplied-air respirators (Fig. 95). Most cartridge type respirators are designed as half-face masks that cover the nose and mouth but do not protect the eyes. They have 1 or 2 cartridges attached to the facepiece by a clamp or secured in a holder. These types usually are equipped with one-way valves that force the inhaled air through the cartridges but bypass the exhaled moist breath around the cartridges. Respirator cartridges usually contain an absorbing material such as activated charcoal, also with an efficient filter that removes dust and spray particles, so as to prolong the life of the absorbing material. The life of chemical-absorbing

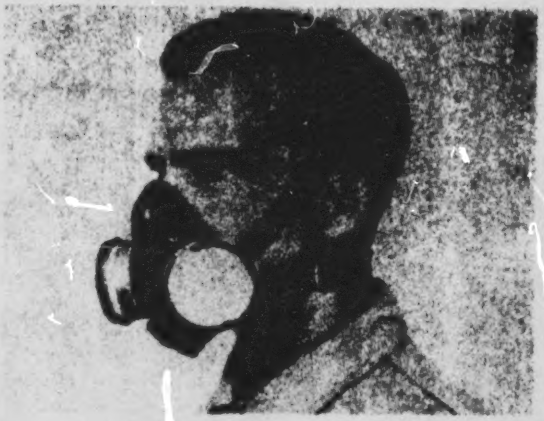


Figure 93 – Commercially Available Cartridge-Type Respirator Adequate for Protection Against Pesticides Under Certain Conditions, Showing Proper Adjustment of Straps

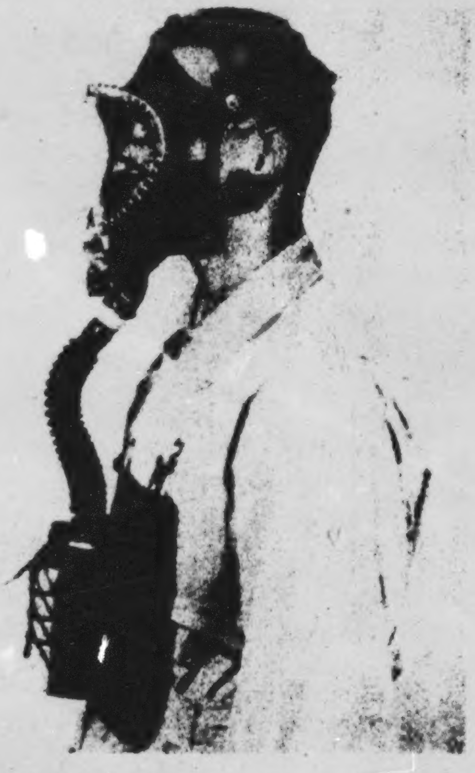


Figure 94 – Gas Mask, Showing Proper Adjustment for Facepiece

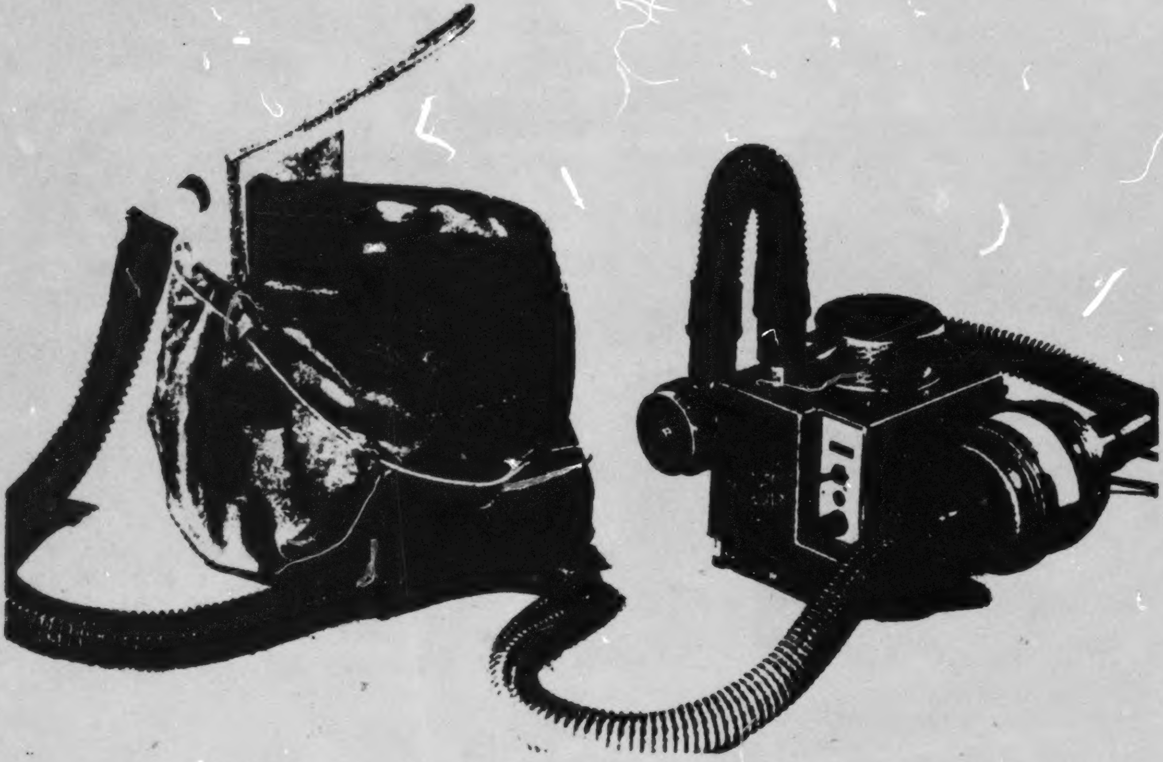


Figure 95 - Supplied-Air Respirator with Blower-Filter and Hood

cartridges or canisters vary according to the concentrations encountered, and also are affected by humidity, temperature, and volume of breathing.

Gas masks usually cover the entire face. Their facepieces are made to hold a canister directly or to connect the canister by means of a flexible hose.

A supplied-air respirator has a combination blower-filter with a breathing hose leading into a hood worn by the operator and incorporating a safety helmet and shield. Due to differences in their protective capacity, supplied-air respirators or gas masks and not cartridge-type respirators must be worn when formulating or mixing pesticides in closed or inadequately ventilated spaces, or if there is direct exposure to concentrated dusts or sprays, such as greenhouses.

When respirators are used, the following practices are necessary:

1. The respirator should be fitted properly on the face. Adjust headbands just tightly enough to ensure a good seal. Manufacturers can usually supply special facepieces if the standard one does not fit.
2. Change filters twice a day or oftener if breathing becomes difficult.
3. Change cartridges after 8 hours of actual use, or oftener if any odor of the pesticides is detected.
4. Remove filters and cartridges and wash the facepiece with soap and warm water after use. Rinse it thoroughly to remove all traces of soap. Dry the facepiece with a clean cloth that is not contaminated with the pesticide. Place the facepiece in a well-ventilated area to dry.
5. Store the respirator, filters, and cartridges in a clean, dry place, preferably in a tightly closed paper or plastic bag.

The use of a respiratory protective device does not eliminate the need for other precautions in handling toxic pesticides. Provide for adequate ventilation of the area where pesticides are loaded or mixed. If an operator shows any sign of dizziness or nausea, he should be removed immediately from the area and placed in the care of a physician before he returns to work.

TRANSPORTATION REQUIREMENTS

Transportation of Class A and Class B poisons is subject to U.S. Department of Transportation

(DOT) Hazardous Materials Regulations when moving in interstate commerce. Detailed information regarding transportation requirements may be found in the following document:

"Safety Manual for Handling and Warehousing
Class 'B' Poisons and Pesticides"
National Agricultural Chemicals Association
1155 15th Street, N.W.
Washington, D.C. 20005

Pertinent provisions of the regulations follow:

Classification. Class A and B poisons are classified in accordance with DOT regulations.

Containers. Completed package must withstand 4-foot drop onto concrete (applies to shippers).

Labels. Diamond-shaped labels are required to be affixed to containers when the movement is by for-hire carriers or when the shipment is to be transferred from one carrier to another.

Container Marking. Standard shipping name on outside container is required under certain conditions.

Placards. "POISON" placards are required for any quantity of Class A or 1,000 pounds or more of Class B poisons. This applies to any vehicle.

Loading Restrictions. No Class B material may be loaded with foodstuffs unless foodstuffs are in "non-permeable" containers. Lading must be secured to prevent movement. In California, flatbed trucks transporting Class A or B poisons must have side and end racks.

Certification. Carriers may not transport Class A or B poisons unless the shipper has certified in writing that the shipment has been prepared in accordance with DOT regulations.

COMBINATION OF CHEMICALS

Two or more chemicals frequently are combined:

1. To increase the effectiveness of one of the chemicals.
2. To provide better control than that obtained from one pesticide.
3. To control different types of pests with a single application.

Synergist

In some instances the activity of a pesticide against specific pests may be enhanced by adding a chemical called a synergist. Synergists are not active pesticides but increases the effectiveness of the pesticide. Synergists usually increase the toxicity of the pesticides so that a smaller amount is needed to bring about the desired effect. This may reduce the cost of the application, and also reduce the hazard, as less of the active material is used.

Addative

Applicators sometimes combine 2 or more active pesticides to kill a pest that has not been effectively controlled by either chemical alone. Many combinations are quite effective, but in most cases it is not known if the improved control is a result of a synergistic action or an additive effect of the several chemicals on different segments of the pest population.

Compatability

Frequently, several types of pests need to be controlled at the same time. Generally, it is more economical to combine the pesticides needed and make a single application. However, the compatibility of the various chemicals must be known before the materials are combined. Some combinations of chemicals result in mixtures that produce the opposite effect of synergism, known as "ANTAGONISM" or "INCOMPATIBILITY." This may result in chemical reactions which cause the formation of new compounds or a separation of pesticides from the carrying agent. One of the following may occur, if this reaction happens.

1. Effectiveness of one or both compounds may be reduced.
2. Precipitation of the toxicant or toxicants may occur and clog screens and nozzles of application equipment.
3. Plant injury (phytotoxicity) may occur (e.g., russeting of fruits and vegetables, stunting, loss of seed germination).
4. Excessive residues may result.
5. Excessive runoff may result.

Potentiation

Another less familiar but extremely important effect of combining certain pesticides is potentiation. Some of the organophosphorus pesticides potentiate or activate each other as far as animal toxicity is concerned. In some cases, the combination increases the toxicity of a compound that is normally of very low toxicity to one that is highly toxic to man and other animals. Phytotoxicity, excessive residue, or poisoning of livestock also can occur when one chemical is applied several days after the application of a different chemical. Chekc the pesticide label carefully for such warnings.

When a combination of chemicals is to be made refer to the compatibility charts that are available through a pesticide salesman or from one of the many pesticides journals. Because of the risks involved, combinations of pesticides and/or other agricultural chemicals should not be used unless the specific combination has been proven to be effective, tested for side effects and accepted for registration by the EPA or your local agriculture department. It is illegal in many states to recommend or use mixtures of 2 or more pesticides if such recommendations or usage conflict with the manufacturer's registered label.

BASIC RULES FOR SAFE HANDLING OF PESTICIDES

Pre-seasonal Preparation

1. Contact your physician for cholinesterase base-line test if you plan to use phosphate or carbamate insecticides.
2. Inform physician of types of pesticides you plan to use.
3. Confirm that your physician has the up-to-date telephone numbers of poison control centers.
4. Post these emergency telephone numbers by your telephone.
   - A) Physician
   - B) Poison Control Center

Selection of a Pesticide

1. Know the pests.
2. Select right pesticide for the job.
3. Read the label.

   Pay special attention to warnings and precautions before opening container.
4. Consider hazards to humans, livestock, pets, bees and wildlife.

Before Using Pesticides

1. Have plenty of clean water and soap readily available, and wash thoroughly after use.
2. Have a clean change of clothing and change each day or after each job.
3. Know First Aid procedures.
4. Have proper protective equipment, if directed on the label.
   - A) Clean hat, gloves, goggles, clothing.
   - B) Check respirator for a clean filter and gloves for holes.
   - C) Change filters as frequently as recommended by manufacturer.
5. Check application equipment for proper functioning, leaking hoses, or connections.
6. Discuss safe use of pesticides with employees.

Handling and Applying Pesticides

1. Observe label directions.
2. Wear proper and clean protective equipment.
3. Handle concentrated pesticides with extreme care and mix outdoors where there is adequate ventilation.
4. Never eat, smoke, or drink while handling pesticides.
5. Never work alone when applying hazardous pesticides and observe each other for any change in normal activity.
6. Stay out of the drift and the runoff as much as possible.
7. Don't apply pesticides when drift will be a problem to humans, livestock, pets, bees, wildlife and crops.
8. Never use more than the recommended amount.
9. Keep public away, especially children, from mixing, loading or application sites.
10. If handling toxic material at night, make sure there is adequate light.
11. Pour liquids, powder and dusts slowly to avoid splash, spill or drift.
12. Open sacks with a knife rather than tearing.
13. Avoid inhalation of chemical dust and fumes.
14. Do not wipe your hands on your clothing if chemical has been spilled on your gloves. This will contaminate your clothing and the chemical may be absorbed by your skin.
15. If a concentrate is spilled on the floor or ground, clean it up or dilute it to reduce possible hazard of contact. Some chemicals in the concentrated form will remain in toxic quantities in the soil for many months.
16. Use separate equipment for applying hormone-type herbicides (such as 2,4-D) in order to avoid accidental injury to susceptible plants.
17. Check your application equipment frequently to ensure proper function and dosage rate.
18. Do not blow out clogged hoses, nozzles or lines with your mouth.
19. Do not contaminate apiaries, fish ponds, lakes, streams or canals.
20. Bathe and change clothing at the end of each day.
21. Launder clothing after each day's use.

Storage of Pesticides

1. Store pesticides in locked, dry cupboard or

shed out of reach of children and other unsuspecting people (Fig. 96). Storage areas should be well-marked with signs. (Fig. 97).

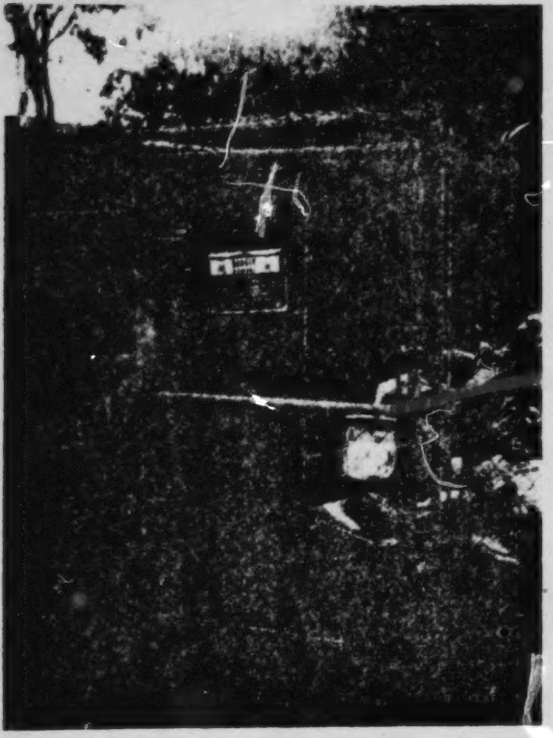


Figure 96 - Pesticides Should Be Stored Under Lock and Key

Figure 97 - Storage Areas Should be Well-Marked with Signs

2. Never store pesticides with or near food, feed, or liquids for drinking.
3. Never store pesticides in other than the original labeled container.
4. Do not store herbicides or defoliants containing chlorates with other pesticides. They can cause fire or explosion.
5. Always keep lids tightened when containers are not being used.
6. Keep all empty containers in secure storage area until disposed of properly (Fig. 98).
7. Do not leave pesticides unattended in the field or at the site of operation (Fig. 99).

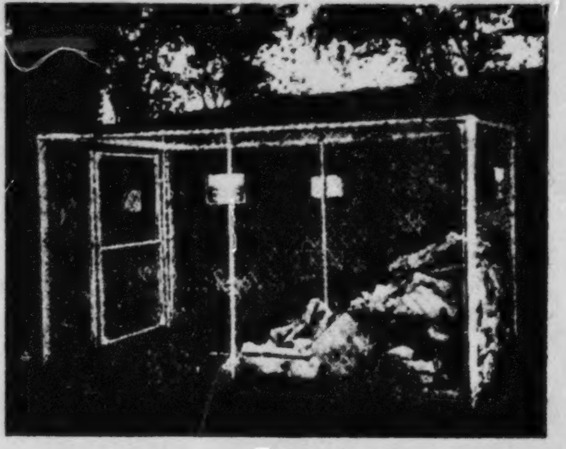


Figure 98 - Empty Pesticide Containers Should be Stored Under Lock and Key Until They Can Be Properly Destroyed

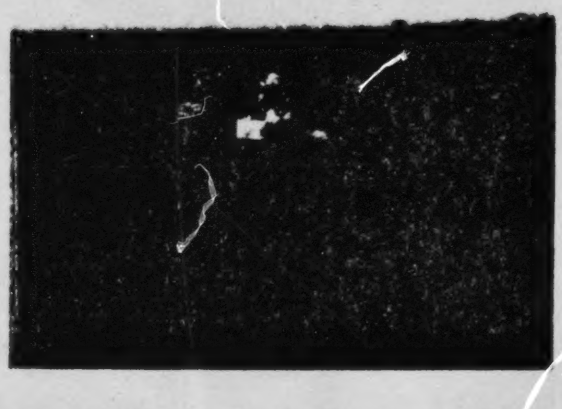


Figure 99 - Never Leave Pesticides Unattended in the Field.

Disposal of Pesticides and Their Containers

1. Dispose of unwanted pesticides in ground where contamination of crops or drainage will not be a problem.
2. Return empty drums to supplier or cooperage firm as soon as possible.
3. Burn combustible containers (paper, cardboard, plastic)(except hormone-type or those containing chlorates). **Caution:** Some localities have restrictions against burning. Consult local authorities before burning container. If burning is not permitted, it would be best to store such containers under lock and key until enough of them are collected to make it practical to transport them to an approved dump site where their burial can be ensured.
4. Rinse, break and put in approved dump-all glass containers. If the above procedure is impractical, thoroughly rinse several times with water and detergent or caustic soda and put rinse solution into a pit in the soil. **Caution:** Handle caustic soda (household lye) with extreme care. Do not get on skin, in eyes or on clothing. Invert container and let it drain for 15 minutes into the pit. Dispose of container in approved dump.
5. Metal containers that have held less than 28 gallons of liquid pesticide should be rinsed and drained by the user at the time of use in the following manner:
   - A) Empty the container in the normal manner; drain an additional 30 seconds.
   - B) Add the correct amount of water rinse, usually 1/5 of the container. Replace the closure and rotate and "end up" container to get the rinse over all of the interior areas.
   - C) Drain the rinse solution from the container into the mix tank. Allow the container to drain 30 seconds after normal emptying.

*Repeat this same procedure at least 2 additional times so as to provide a total of 3 rinses. It is important that the rinse solution go into the mix tank and go on the crop where it was intended to go in the first place.

6. Aerosol containers should never be burned or punctured; put them in a dump.
7. Never stand in fumes or smoke of burning pesticides of containers.

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LEARNING AT HOME
Review Questions – Section 5

1. Most risks encountered in the use of pesticides occur while __________.
2. Most safety problems in the use of pesticides are encountered while using ________.
3. Which type of formulation presents the most serious safety hazard __________.
4. Pesticides are more hazardous to apply when __________.
5. What medical test is used to confirm over exposure to organophosphates __________.
6. Name 5 organophosphate pesticides:
   a. _______________.
   b. _______________.
   c. _______________.
   d. _______________.
   e. _______________.
7. The __________ is the area of the body which is the most likely potential route of entry for pesticides.
8. It is more hazardous to work with pesticides above what temperature __________.
9. Organophosphates inhibit an enzyme which __________.
10. While mixing pesticides, the most important item of protective clothing is: __________.
11. The chemical group of pesticides having the greatest use hazard is __________.
12. Some of the early symptoms of organophosphate poisoning are: __________________.
13. The time of day which is most hazardous to mix and apply pesticides is __________.
14. A restricted pesticide is one which: ________.
15. Net contents of a liquid formulation of a pesticide shall be expressed in a label in terms of __________.

OUTSIDE ASSIGNMENTS

1. Using the information on the labels you have, compile your own check list of steps to be observed in safe handling of chemicals.
2. Observe the plant you are working in or operating. See how many unsafe conditions or practices that exist. Make a list and what steps would be necessary to correct them.

PESTICIDES

Edward W. Bushing
Entomologist
Paramount Pest Control Service
Sacramento, California

INTRODUCTION

A pesticide is defined as a substance or mixture of substances intended for destroying, repelling or mitigating any pest. A pest is any living thing that exists where it is not wanted. Ideally, a pesticide should control a pest but not be detrimental to humans or other non-target organisms in the environment.

The following is a brief glossary of pesticides used in the pest control industry:

Pesticide	Used Against
Acaricide (Miticide)	Mites
Avicide	Birds
Fungicide	Fungi
Herbicide	Weeds
Insecticides	Insects and related animals such as spiders, millipedes and centipedes
Molluscicides	Snails and slugs
Nematicides	Nemotodes
Rodenticides	Rats, mice or other rodents

HOW INSECTICIDES ENTER THE INSECT BODY

Insecticides enter the insect body by 3 common ways; by contact, as stomach poisons or as fumigants. Many pesticides may enter the body by more than one of these possible routes.

Contact Insecticides

Insecticides in this class kill pests by contacting and entering their bodies either directly through the integument into the blood or by penetrating the respiratory system through the spiracles into the tracheae. These materials may be applied directly to the insect body or as a residue on plant or animal surfaces, habitations or other places frequented by insects. In cases where residues are used, pests usually contact the pesticide through their tarsi. Generally speaking, coarse sprays or dusts are a more effective means of applying contact insecticides than are mists or fogs. Most of the synthetic organic compounds act as contact insecticide, although many also confer stomach and fumigant activity.

Stomach Poisons

Stomach poisons must be swallowed in order to cause death. They may be formulated as liquids, dusts, pastes, granules or baits. In the case of liquids and dusts, the pesticide is usually applied to some substance on which the animal will chew or walk through. Pastes, baits and granules may be formulated with a feeding attractant which is consumed by the pest. Inorganic and botanical insecticides in general are predominately stomach poisons. Some synthetic organic insecticides may also act in this capacity.

Fumigant Pesticides

Gaseous poisons used to kill pests are called fumigants. Their applications are usually limited to materials, structures or organisms that can be or are enclosed in a tight enclosure. There are many fumigants, some distinctly odorless, while others are used in conjunction with odorless fumigants as a warning agent because of their odor. Many can be used safely about food products and most are very stable at stipulated temperatures. Some combine with commodities to produce corrosion or undesirable gases. When properly used, a fumigant is non-flammable and unlike any other forms of pesticides, kills all the development stages of an animal. In the case of insects, this includes the egg, larvae, pupae, and adults. When a fumigant reaches the appropriate concentration, it will kill pests quicker than any other pesticide.

MISCELLANEOUS PESTICIDES

This group includes pesticides which may enter the body through any one or more of the previously mentioned means, but have some specialized mode of action or means of application.

Systemic Insecticides

Systemic insecticides act mainly as stomach poisons. However these chemicals are typically applied to one area of a plant or animal and are translocated to another area. In the case of plants, systemics are typically applied to the roots or stems of a plant and move through the vascular system to the leaves. Examples are Systox , Thimet and Disyston.

Dessicant Dusts

When applied to an insect, these materials absorb or abrade off the outer waxy layer of the insect's cuticle, causing the loss of body fluids and death by dehydration. The common dessicating dusts used by pest control operators are silica aerogel and boric acid.

Chemosterilants

There are chemicals which cause sexual sterility in either the male or female insect or animal. Chemosterilants have not yet been used on a commercial bases.

Pheromones

These are chemicals which may be of potential use in preventing insect mating when used to saturate the habitat.

Antimetabolities

These are chemicals which interfere with the normal metabolic or physiological processes of animals.

PESTICIDE GROUPS

Pesticides classification or grouping may be based on any of several criteria. One of the most common means of classifying pesticide is on the basis of similarities in chemical structure. Based on this mode of classification, there are 3 classes of pesticides commonly used in the structural pest control industry, the inorganic, botanical and synthetic organic insecticides.

Inorganic Pesticides

Inorganic pesticides are typically derived from minerals or chemical compounds that occur as deposits in nature. These pesticides were used extensively from about 1850 until WW II. Since then, the use of most inorganic pesticides has decreased appreciably and few inorganic pesticides are used today. A few exceptions are boric acid, sulfur, and the silica aerogels.

Being inorganic in nature, most of these compounds are quite stable and tend to accumulate in the environment. The use of some of these compounds are banned in many parts of the country. Most act as stomach poisons and with the exception of those commonly used today, are considerably toxic to man. Many of the inorganic pesticides are relatively expensive and are only moderately effective in controlling insects and other pests. Common inorganic pesticides are lead arsenate, Paris green, sodium arsenite, calcium arsenate, sodium fluoride, cryolite, sulfur, and thallium sulfate.

Botanicals

The botanical pesticides are extracted from various parts (stems, seeds, roots, flower heads) of different plant species. Most of these pesticides are relatively non-toxic to man. Notable exception is nicotine and strychnine which is very toxic to mammals. Botanical insecticides have a short residual activity and do not accumulate in the environment or in fatty tissues of warm blooded animals. Most botanical pesticides act as stomach poisons, although pyrethrin is mainly a contact poison.

The main drawback with these type chemicals is that since they are extracted from plants and are too complex in structure to be synthesized by man, they tend to be expensive. The fact that they are extracted from plants limits the amounts of these chemicals that are available for pest control. Common examples of botanical pesticides are pyrethrin, sabadilla, rotenone, hellborne, ryania, nicotine and strychnine.

SYNTHETIC ORGANIC INSECTICIDES

Synthetic organic insecticides do not naturally occur in the environment, but are synthesized by man. Since all these compounds have carbon and hydrogen atoms as the basis of their molecule (as do living plants and animals), they are referred to as organic compounds. The 3 basic types of synthetic organic insecticides are the chlorinated hydrocarbons, organophosphates and the carbamates.

Chlorinated Hydrocarbons

This large group of insecticides vary considerably in toxicity to mammals. Most are only moderately toxic, however, a few, such as endrin are very toxic to mammals. The use of these materials has recently been severely criticized for their effect on the environment. Most chlorinated hydrocarbons are very stable and do not readily decompose in the environment. The problem of the accumulation of these compounds in the environment is compounded by the fact that the chlorinated hydrocarbons tend to accumulate in fatty tissues. This results in the "building up" of these materials in food chains. The death of many types of wildlife (especially the young) have been attributed to these chemicals. Many of the chlorinated hydrocarbons are relatively inexpensive. These pesticides act mainly by contact although there is also considerabel stomach poison activity. The use of several of the chlorinated hydrocarbons has been prohibited or restricted in many areas of the country. Examples of the chlorinated hydrocarbons are DDT, BHC, dieldrin, chlorodane, aldrin, endrin, heptachlor and methoxychlor.

Organophosphrous Compounds

The organophosphates are an extremely large and diverse group of compounds which have unlimited possibilities as pesticides. There are presently 40 to 50 of these pesticides being used today. Their toxicity to mammals range from extremely toxic to some of the least toxic pesticides known. Most organophosphrous compounds are not persistent and will break down to non-toxic material in nature in 1 to 30 days, depending on the compound. Organophosphates do not accumulate in fatty materials and do not accumulate in food chains. These compounds act mainly as contact insecticides although they may also confer some stomach and fumigant activity. Although there have been some death from these compounds, these have mainly resulted from misuses or carelessness. Common organophosphates are malathion, Dursban®, parathion, methyl parathion, guthion, diazinon, Vapona®, Cygon® and Dibrom®.

Carbamates

The carbamate compounds are the newest large group of compounds to be investigated and commercialized for use as pesticides. As a rule, these compounds are slightly more persistent in the environment than the organophosphrous compounds, but do not accumulate in the environment or fatty tissues of mammals. Most of the commonly used carbamates are only moderately toxic to mammals. The compounds mainly act as contact insecticides with some stomach activity. Common carbamate insecticides are Sevin®, Bagon® and Zectran®.

TYPES OF FORMULATIONS

This section will deal with the construction of a formulation, mainly the active and the inert ingredients. Since pesticides only rarely consist of the technically pure toxicant, there are various substances added to the toxicant to dilute it and enhance its activity (e.g., formulated). Some common substances or diluents are special petroleum solvents, talcs and clays, wettable and soluble powders, granules, and special liquid gases (aerosols). Also present in formulations are substances which facilitate the distribution of the pesticide and, in some instances, stablize or intensify the pure material. In almost all instances, pesticides are formulated when received by the pest control operator. Instructions on what the operator should do to apply the pesticide are always given on the label

Also found on the label is a statement as to the active ingredietns found in a formulation. The active ingredients are materials in the formulation which are toxic to the pests. The active ingredients not only include the pesticide itself but other materials which are added to the pesticide for formulation purposes that may in themselves confer some toxic effect on the pest (e.g., petroleum distilates). Also on the label is a statement as to the inert ingredients present in the formulation. These are substances generally considered not to be toxic by themselves. Their presence is only to facilitate the applicability of the active ingredients.

LIQUID PESTICIDE FORMULATIONS

Emulsifiable Concentrates

It is well-known that oil and water will not mix. However, if a small amount of soap is added to the mixture and the mixture is agitated, the oil will form very small droplets and will become dispersed throughout the water. This is known as an emulsion. This is a basic process of how emulsifiable formulations are prepared. Most synthetic organic pesticides are not soluable in water but are soluable in oil-based solvents. The toxicant of an emulsifiable concentrate is dissolved in a small amount of suitable oil-based solvent and a liquid soap called an emulsifier is added. Most emulsifiers are not simple soaps but instead are made up of a variety of complex soaps, each intended for a specific purpose. Other ingredients which improve wetting, sticking or spreading (adjuvants) may also be added. Most products of this type appear as light to dark amber colored liquids which may be about the same consistency as water or as heavy as syrup. Some emulsifiable concentrates look very similar to popular soft drinks or alcoholic beverages and should never be stored even temporarily in non-pesticide containers.

Most emulsifiable concentrates are sold with the highest amounts of active ingredients as possible. The solubility of the active ingredients in commercially available solvents may limit the amount that can be put into each gallon. Most emulsifiable concentrates contain between 1 and 6 pounds of active ingredient per gallon of formulation. The product's label must contain this information.

With most emulsifiable concentrates, water is added at the time of application. However some special purpose emulsions are made to be used with carriers other than water and are formulated with the carrier already present in the formulation. Highly refined oils or kerosene-type petroleum solvents are the other carriers most often used

Flowables

The active ingredient of some pesticides is not liquid nor is it soluble enough in any solvent (especially carbamates) to manufacture an emulsifiable concentrate. The best way to manufacture these products as liquids is to make flowable formulations. After the active ingredient is ground to a very fine powder, special chemicals are added to keep the powder suspended in a *liquid, usually water. Other chemicals that* improve wetting, sticking, spreading may also be added. Well-formulated flowable products may be stored on the shelf for a year or more before any appreciable amount of the powder settles to the bottom of the container. In practice, any flowable formulation should be shaken well before being added to water or other spray carriers. If the powder has settled and the container is not shaken, improper rates will be applied. Only moderate agitation is needed in the spray tank. Modern flowable formulations seldom cause clogging of spray nozzles.

Most flowable formulations are opaque in color and have the consistency of a moderately thick milk shake. They vary in color from pure white to light beige or gray and usually contain from 2 to 6 pounds of active ingredient per gallon. This formulation is preferred over a wettable powder for highly toxic compounds or for those chemicals which are difficult to wet. There is no dust hazard as there would be with a wettable powder and thorough wetting is accomplished during manufacture.

Aerosols

Aerosols are very fine mists with the diameter of the individual droplet varying from 5 to 50 microns. They may be produced by the use of heat from a gasoline engine or any heat generating device. With heat generators, the pesticide is pumped through a fine orifice into a heat chamber. The sudden expansion of the pesticide from the heat propels it out the application tube as a fog or smoke.

Another common method of aerosol generation is by a compressed gas method where the pesticide is mixed with cold compressed liquified Freon. This is placed in a can with a very fine orifice nozzle. With the temperatures of 60 to 100°F., compressing the nozzle releases a very fine mist. In either instance, the fog or mist is very penetrating and is usually used interiorly. Outside use of aerosol may quickly result in undesirable drifts of the pesticide to unwanted areas.

DRY PESTICIDE FORMULATIONS

Dusts

Dusts are a pesticide formulation where a toxicant is added to an inert carrier such as talcs, clays, walnut shell flour, diatomaceous earth or pyrophyllite. Dusts can be made by dissolving the toxicant in an organic solvent such as acetone or benzene, or the technical grade toxicant may already be in a liquid form. In either case, the liquid may then be atomized on the inert solid carrier while it is being mixed. If desirable and the toxicant is a solid, it may be ground and then mixed with the inert carrier. The concentration of the toxicant in a dust formulation is usually low, 1 to 10 percent by weight. Dusts usually disperse very effectively in enclosed spaces and have good penetration powers. The most significant disadvantage of this type of formulation is its uncontrollable drift. Dusts are also hazardous from the standpoint of inhalation.

Granules

As with dusts, the toxicant is added to a carrier or diluent. In this case, the carrier is considerably larger in size than the dust carrier. A commonly used granule size is 15/30. This means that 95% of the granules will pass through a 15 mesh screen (15 holes per square inch) and not more than 5% will pass through a 30 mesh screen.

Typical granule carriers include talcs, clays, walnut shell flour and vermiculites. They are initially formulated in a similar manner as the dusts. With the addition of a binder, the substance is made into pellets or granules. As with dusts, the final product of the pesticide granule is in a form ready for use. Seldom is there a drift problem with granules, but the size of the granules lend themselves to being picked up by children and animals. Many granules are coated with non-toxic materials which make them comparatively safe to handle.

Wettable Powders

Wettable powders, one of the most commonly used formulations, look like and essentially are highly concentrated dust formulations. However, they also contain wetting and dispersing agents that, unlike dusts, allow them to be mixed with water to form a suspension. Any wettable powder formulation tends to settle out unless sufficient agitation is used to keep the particles suspended. Wettable powders are almost always more concentrated than dusts and emulsifiable concentrates and usually contain between 30 and 90 percent active ingredient. Concentrations of 50, 70 and 75 percent active ingredient are most common. The bulk of the remaining part of the formulation is made up of inert carriers such as talcs, various clays (bentonite), diatomaceous earth, calcium carbonate, and walnut shell flour.

Wettable powders vary in color from white to beige or gray. When pouring the powder into water, care should be taken to place the bag inside the spray tank before pouring to avoid exposure to the dust. Most well formulated wettable powders mix easily and suspend well in water. The carrier may cause abrasion of pumps and nozzles after long term use. Since wettable powders contain no solvents to penetrate plants they, as a group, are less likely to cause plant injury than emulsifiable concentrate formulations.

Baits

These pesticides may be carried in liquid or dry materials. In some instances, the diluent or attractant may be a by-product of the food industry such as apple pulp, ground corn cobs, bran or hulls of seeds. Even sawdust has been a common carrier. No variation of the shape of the dry diluent is attempted; consequently, baits have the appearance of the diluent used. Liquid baits have been manufactured for a long time for the control of ants, but today are also used for fly control. In the latter case, the pesticide is incorporated with a sweet liquid, normally a sugar derivative. Being a liquid it is placed in a sealed container which has a wick exposed to the environment and the pest. This not only facilitates the pest but may lend to poisoning of children and pets.

Soluble Powders

The active ingredients of some pesticides are dry powders which are naturally soluble in water. During manufacture, other chemicals may be added to improve flowability of the formulation, wettability (plant parts), or stability of the active ingredient. Some agitation may be needed initially to help dissolve soluble powders but after a solution is obtained, agitation is not required.

At first glance soluble powders seem like ideal products from the standpoint of mixing and spraying. However, they can be incompatible with extremely acid or alkaline water or when mixed with other products. Most soluble powders are white to beige or gray powders which may appear somewhat granular like sugar. The percentage of active ingredient in these formulations is usually in excess of 75%.

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LEARNING AT HOME

Review Questions – Section 6

1. A pesticide used against weeds is called ________________.
2. A pesticide used against insects is called ________________.
3. Botannicals include ________________.
________________.
4. Name 4 organic pesticides:
a ________________
b ________________
c ________________
d ________________
5 Name 4 chlorinated hydrocarbon pesticides:
a ________________
b ________________
c ________________
d ________________
6. Contact pesticides kill pests by:
____
____
7. Chemical which cause sexual sterility in a pest is called a ________.
8. Name 3 common substances used to dilute pure chemicals to create a formulation:
a ________________
b ________________
c ________________
9. What is the meaning of compability when speaking of pesticides
____
____
10. The purpose of the inert ingredients in a formulation is
____
____
11. The purpose of emulsifiers in a formulation is:
____
____
12 Aerosols are very fine mists and particle size is usually less than ________ microns.
13. Name 3 diluents used in a dust formulation:
a ________________
b ________________
c ________________
14. Wettable powders contain ________________ that allow them to be mixed with water to form a suspension.
15. What substance, other than a pesticide is usually added to a bait: ________.

OUTSIDE ASSIGNMENTS

Construct a Table along the lines of the one in Section 2. List all information of importance. Example:

Trade name
Chemical name
% active ingredient
Group (Organophosphate-Chlorinated Hydrocarbon, etc.)
Category
  Signal words
  Type formulation
  (Any others you consider important)

This too is good reference material for your notebook.

EQUIPMENT AND TECHNIQUES OF APPLICATION

Authors:

Equipment –
Edward W. Bushing
Entomologist
Paramount Pest Control Service
Sacramento, California

Techniques of Application –
Eugene D. Young
Kellogg West Center for
Continuing Education
California State Polytechnic
University

INTRODUCTION

It might be said that the choice of equipment for pesticide applications is only as efficient as the knowledge of the person using that equipment. In other words, it is imperative that the pest control operator acquaint himself with the limitation of whatever device he chooses, so the ultimate in control can be accomplished. Ignoring this simple axiom causes, perhaps, more failure in the control of pests than any other factor.

The proper maintenance of pest control equipment is almost as important as making the correct choice of equipment for a particular job. Obviously, any amount of expertise is diminished by malfunctioning of equipment. It is not important if the details for repairing equipment is from memory or from a manual that is readily available, if a breakdown occurs. Homemade equipment or devices not considered as standard productive pesticide applicating equipment on the market still must conform to all applicable government regulations. Label instructions with regard to the application of a pesticide usually govern the type of equipment which is permitted to be used.

In order that the information in this publication may be more intelligible, it is sometimes necessary to use trade names of the product or equipment rather than complicated descriptive or chemical identifications. However, no endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

Pesticide applicators utilize many methods in the application of pesticides. Most of these have been developed as the result of years of studying the most effective methods. Some of the methods, however, may result in problems such as over application, not reaching the pest habitat while using a minimum amount of pesticide, and depositing unsafe residues. Proper techniques of application not only aid in effectiveness but also ensure workers' safety, public protection and protection of the environment.

Competence in pest control includes basic knowledge of pests and pest problems, the ability to choose the right pesticide and equipment and a knowledge of proper methods of application. The proper technique of application probably plays a greater part in a successful job than all the others.

The applicator tends to take short cuts in application. He may use too much pressure in power spraying which creates voids in the spray pattern. He may fog when a careful needle point spray directed in the proper place would be more effective. Fancy fogging machines will not substitute for a thorough search of all cracks and hiding places and the application of just the right amount of pesticide with even a crude hand-held sprayer. A brief resume of the types of pesticide equipment and techniques of application is presented in the following section.

DUSTERS

Dust formulations are pesticides in which the active ingredient is mixed with a substance which is usually light in weight (talc or clay). However, heavier weighted carriers are also essential for the proper distribution in certain situations. Many lightweight dusts are not acceptable in many areas since they may be a hazard to the applicator or the vicinity in which the application is made. Ultimate drift of dispersed dust must be of considerable concern to the applicator. Precautionary measures in the use of dust equipment consist of the following:

1. Because dusts are usually exerted under some degree of pressure, all working parts of the equipment should be carefully examined. All literature provided by the manufacturer should be carefully read.
2. Goggles and respirators should be included in the safety equipment.
3. The operator should be acquainted with the operations and limitations of each piece of equipment he uses.
4. Complete removal of dust remaining in the hopper and any extensions of the duster should be accomplished after the completion of each job.

Hand Operated Dusters

Getz Applicator

This is a very simple device in which a spring is surrounded by a rubber sleeve sealed at one end by a filler plug and the other by a small release tube (Fig. 100). Contracting the 2 ends compresses the spring and releases a limited quantity of dust through the tube orifice. Releasing the grip on the spring forces the sleeve to resume its original position. The capacity of this device is very small (6 ounces) and usually it is only used for cracks or crevice treatment. Small void areas can be expertly treated with this device.

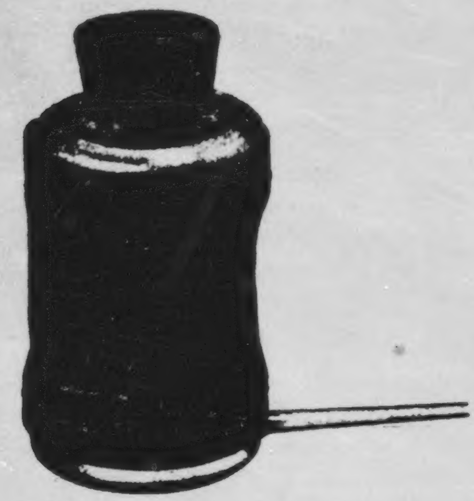

Figure 100 – Getz Applicator

Flexible Bulb

This is similar to the Getz applicator but does not depend upon a spring to re-establish its flexibility. Instead, by the nature of its construction, it resumes its original shape and upon compressing releases dust through a small orifice (Fig. 101). Depending upon the weight of the dust used, it may hold slightly more than the Getz applicator. Its uses are identical as for the Getz applicator.

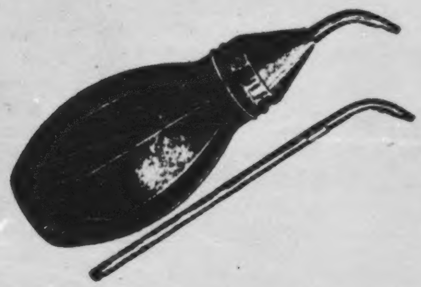

Figure 101 – Flexible Bulb Duster

Plunger Tube Dusters

This is a device in which a plunger forces air through a cylinder into a small tube of varying length. Retraction of the plunger allows air and dust to mix in the cylinder and upon depression of the cylinder, repeats the above process. This device is suitable for crack, crevice, or void applications. Its capacity is usually greater than both of the previously mentioned dusters.

Hand Crank Dusters

These dusters have a hopper for the dust which varies in capacity from 1 to 10 pounds. At the bottom of the hopper is an orifice which is adjustable in size and which allows the dust to fall into an air stream created by fins attached to a shaft. The shaft in turn is attached to a crank which is driven by hand power. A tube of varying length leads from the hopper to the final area of dispersion. This unit is typically used exteriorly or occasionally under the sub-areas of a house.

Foot Pump Dusters

This is really a duplication of the plunger type duster but in the place of the fixed release tube, a hose is substituted and a place to set the operator foot is provided. The plunger propels the dust through the tube, usually into a rodent burrow. In most cases this style of duster is used in exterior areas.

Power Dusters

As their name implies, the following equipment either uses electric motors, gasoline engines, or compressed air as the power to run the mechanism which propels the dust. Where the hand type units usually are for small applications, power dusters obviously are used where large quantities of dust are to be dispersed. In the structural pest control industry, this type duster is usually reserved for use in large enclosed areas such as attics or sub-areas. However, where necessary and practical, exterior application is in order. Drift hazard and time of application are definite limiting factors in their use.

Electric Motor Powered Dusters

This equipment, as indicated by the name, uses an electric motor which powers the propeller that creates the air to force the dust through an applicator tube (Fig. 102). The hoppers for these dusters usually hold from 5 to 15 pounds. One distinct limiting factor is the necessity for the availability of electricity which, in some instances, could limit the application area.

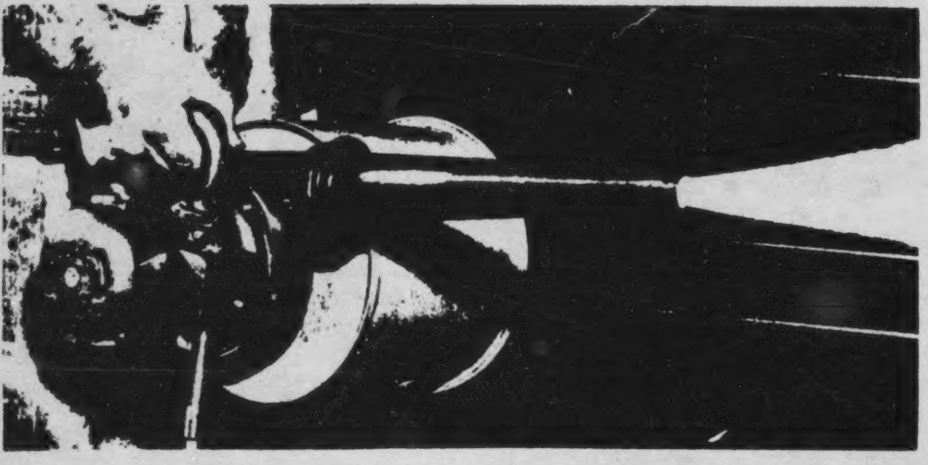

Figure 102 – Power Duster, Operated by Electricity

Gasoline Motor Powered Dusters

The most common example of this is the knapsack or backpack duster. However, there are also wheel-mounted units for large scale applications. In this type of duster, gasoline-operated engines accomplish the same effect as outlined above for the electric motor. Particularly with the knapsack or backpack, there is an extremely large area of mobility because the power unit is self-sustaining. Also, many of these units can be used with minor changes for both dust or liquid applications. The hopper in the case of a dust applicator has a capacity of 5 to 25 pounds.

Air Pressure Dusters

This type of duster is a modification of the fire extinguisher so as to enable the air pressure built up within the tank to expel dust through a hose (Fig. 103). Its limitations are that the quantity of dust is small (1 to 2 pounds) and additional equipment must accompany the unit to build up the air pressure. A truck-mounted air compressor or gasoline facilities also could be used. Once the unit has been filled with dust and pressured with air, it is self-sustaining until either the dust or air is dissipated. Except for the above limitations, it is a very flexible piece of equipment for treatment of cracks, voids, sub-areas, and attics.

Figure 103 – Air Pressure Duster

SPRAYERS

There are many ways to classify equipment in this category. The present system is based on the method by which the pressure is originated to force the liquid from any designated holding container.

Hand Operated Sprayers

Flit Gun

This is probably one of the oldest types of sprayers used by the industry. Its basic principle of operation is that a plunger for developing air pressure is situated above a small supply container. As the plunger is compressed, air is diverted through a small hole situated above a syphon tube from the supply container. The stream of air passes over the tube, syphons the liquid from the tank and atomizing it as it reaches the air supply (Fig. 104). Because of tremendous advancements in equipment, this type of sprayer is seldom used today in the structural pest control industry.

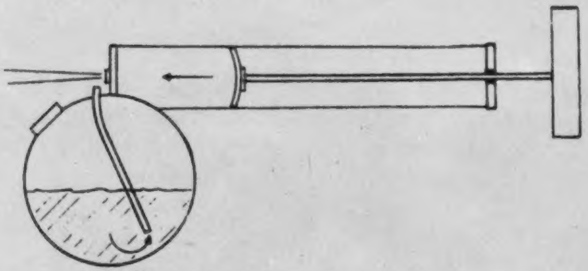

Figure 104 – Flit Gun Sprayer

Small Hydraulic Sprayer

This sprayer is the adaptation of the equipment that used to be used in service stations to spray oil in a pin stream to springs and other lubricated parts of an automobile. It consists of a small supply container, rarely exceeding a quart. Inserted into this container is a tube enclosed plunger which is connected to a hand-pulled trigger (Fig. 105). By exerting pressure on the trigger, the plunger forces liquid through a tube to an adjustable nozzle. The nozzle can be adjusted from a pinpoint spray to cone shape. Either oil base or stable emulsions can be used in this equipment. More often than not, this sprayer is used to apply a residual insecticide rather than a knock-down formulation. One distinct disadvantage is the small capacity of this applicator. This type of application has few uses for spraying the yard and sub-area.

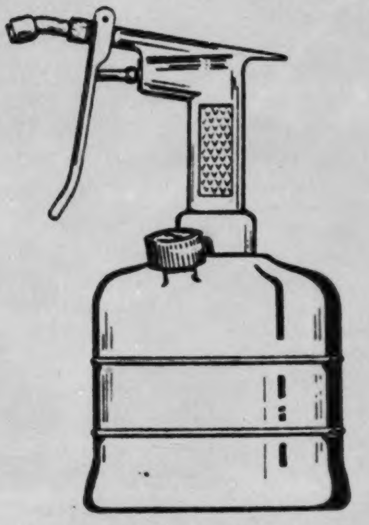

Figure 105 – Small Hydraulic Sprayer

Compressed Air Sprayers

This is probably the most commonly used sprayer in our industry. It is composed of a tank (usually holding from one-half gallon to 3 gallons of liquid), a pump to compress air, and a discharge hose with a valve to control the discharge through a nozzle (Fig. 106). Its operation is relatively simple. An airtight tank, preferably stainless steel, is filled approximately to three-fourths of its capacity with a pesticide (Fig. 107). The remaining space is utilized for the compressed air to be generated by the hand-powered plunger type cylinder within the tank. A check valve is located at the bottom of the cylinder to allow the air to enter the tank but closes to prevent the liquid from entering the cylinder. A tube within the tank is located so that its source originates near the bottom of the tank and discharges to a connected hose. Somewhere prior to the nozzle is a hand-controlled shut-off valve. There is usually a pressure valve where the pipe emerges from the tank and the hose connection. The sprayer should not be used with pressures exceeding 50 psi nor less than 25 psi. The nozzle can be either a multipurpose type (pin stream to fan or hollow cone) or a fixed pattern. This type of application is usually confined to inside work and sometimes outside in monthly service calls. Probably the greatest use in this type of application is in cockroach clean-out calls. An electric or gasoline-driven air compressor could be used to generate the air pressure with this type of sprayer. However, this limits the flexibility of the unit.

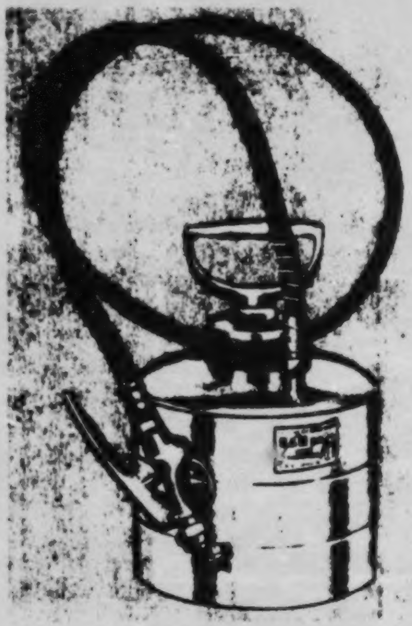

Figure 106 – Compressed Air Sprayer

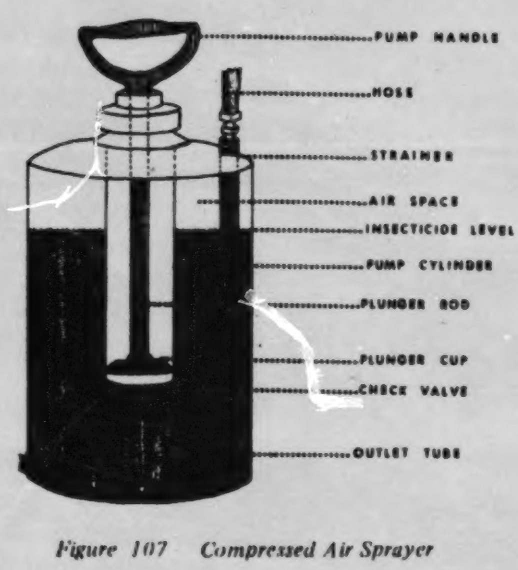

Figure 107 Compressed Air Sprayer

Electric or Gasoline-Operated Sprayers (Powered Spraying)

For the most part power spray usually refers to the typical 50 to 100 gallon spray rigs owned by most structural pest control firms. Most will have some form of agitation, either jet agitation or blades mounted inside the tank. When spraying either a yard or sub-area, a moderately low pressure with a relatively high volume will aid in a safe even distribution. Where grass or weeds are thick it may be necessary to adjust the pressure upwards to be sure and drive the pesticide down into the soil or turf. However, the spray pattern should be kept coarse to ensure wetness.

Low pressure-high volume is particularly valuable when spraying a dry, dusty sub-area. High pressure tends to ball up the top layer of dust or soft soil and move it around in a sweeping motion, without ever getting the soaking action that is desirable. Needless to say, but some servicemen will use higher pressures to speed up a job. A conscientious applicator will move about with a low pressure-high volume type of application and reach all areas.

With power spraying the source of power is either an electric or gasoline engine (Fig. 108). This power can be transmitted to the pump by belts and pulleys, chains and sprockets, power take-off assemblies, or direct drive. In all cases, the liquid is ejected by the action of a pump through hoses or wands and finally through a nozzle or groups of nozzles. In this industry, the most commonly used type of pumps are the centrifugal, gear, and piston pumps. The selection of a sprayer must obviously be governed by the magnitude of the job.

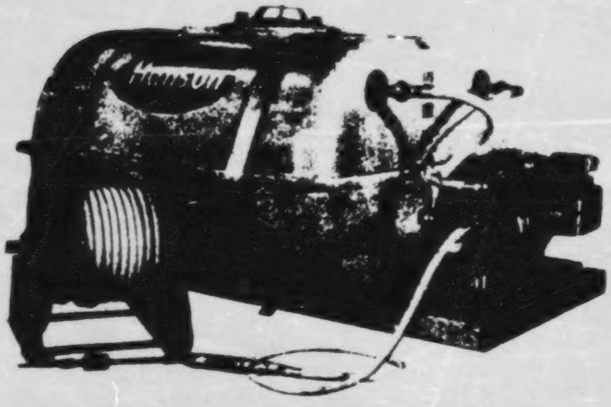

Figure 108 – Gasoline Power Operated Sprayer

Various types of formulations also play an important part in deciding the tank, pump, hose, regulator or nozzle to be used. The following section indicates the various ramifications of this selection by pointing out the various components of some of the systems now in use.

Tanks

They should be of a capacity commensurate with the job. This seems, in most cases, to be of the 50 to 100 gallon capacity. There are tanks available as large as 500 gallons. The tank should be made of either stainless steel, aluminum, fiber glass, plastic, or steel which is coated interiorly with a protective lining or is galvanized. The filling opening should be large, equipped with a strainer, and be of a size large enough to enable easy access for repair of the lining or any mechanical device within the tank. A secure hatch should cover the filling opening to avoid spillage of the formulation while in use. In order for the tank to be adaptable to all types of formulations, it should have a mechanical agitator or a properly placed return of the overflow from the regulator. A drain should be located at the lowest point of the tank and, preferably, should be easily accessible. The inlet to the pump should be of adequate capacity to supply the needs of the pump. An exterior plastic or glass liquid level gauge should be available to check the actual or remaining quantity of pesticide in the tank. All of these newly developed tanks and liners have been developed to overcome the serious problem of corrosion.

Pumps

A pump is the most important part of a spraying system. It is imperative that it be chosen to satisfy the widest range of applications unless its use is for a single purpose. In most instances, the pump comes as an integral part of a complete unit in which the engineering requirements have all been satisfied. In other words, it has been specifically designed and manufactured by a company in this field. As one can imagine, there are many styles of pumps, some specifically for high gallonage delivery with little pressure, while others are styled for both small and large delivered quantities and high pressure. The most common type of pumps are discussed in the following section.

1. Piston Pump

   This is one of the most common pumps in existence (Fig. 109). It has the ability to produce large volumes at high pressures; for example, 55 gallons per minute at 800 psi. However, it can also be regulated to deliver 2 gallons per minute at 150 psi. The only feature which makes this type pump undesirable is its pulsating action on hoses and regulators which causes them to wear at a rate faster than that with other type pumps.

Figure 109 – Piston Pump

2. Centrifugal Pumps

   This type pump is best noted for its ability to deliver high volumes of liquid at low pressures. These are constructed to handle corrosive and abrasive materials.

3. Roller Pumps

   This is a very popular pump in the industry because of its wide variety of uses (Fig. 110). It has either nylon or rubber rollers and can produce a wide range of volumes and pressures.

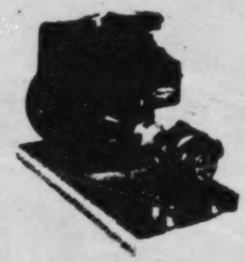

Figure 110 – Roller Pump

4. Internal and External Gear Pumps

   This is a high pressure pump which produces limited volumes. Although all pumps diminish in efficiency from wear, this is more critical in this specific model.

5. Diaphragm Pump

   This is a low volume pump. The main restriction is relative to using a material which will not affect the material of the diaphragm

6. Flexible Impeder Pump

   A pump restricted to low pressures and limited volume.

7. Vane Pump

   This pump requires materials which afford some lubricating properties.

Hoses

The object of any hose is to convey a liquid from the power source to the target. The material of which hoses are made varies considerably. Originally, most were constructed of natural rubber, but today, synthetic rubber, plastic or both are commonly used. As with so many other aspects of equipment in this industry, it is important to know what is expected of the hose relative to performance. For example, is it to carry only oil or water solutions. Are either of these damaging to the center core of the hose? Secondly, under what pressures are the liquids to be carried? Lastly, will the exterior cover withstand normal abrasion? Naturally, such things as capacity of delivery (interior dimension size and friction loss) and material composition of the hose are important in selecting a hose. It is also important to know what specific gallonage delivery is required at the nozzle or group of nozzles. Much of this information is available from the manufacturer, but it should be verified by experimenting with the equipment before it is used. One method of experimentation is to attach the hose to the pump outlet, set the pressure regulator at a specific pressure and attach a nozzle which in turn can be directed into a container. The quantity delivered per minute will determine the gallonage produced by the pump.

Nozzles

There are many types of nozzles. Of primary concern is that the specific type provide the pattern desired. In most cases, the pattern is confined to a solid or pin stream, to a fan, or to a hollow or solid cone nozzle (Fig. 111). Many of the above combinations are available in adjustable nozzles. In most instances, the nozzles are made of brass but can also be made of stainless steel, aluminum, or some wearable parts of plastic. Except for nozzles used on small equipment, the gallonage delivered by a specific nozzle, regardless of design, should be clearly known by the applicator. The capacity of the pump, the pressure on the liquid, the friction loss and size of the hose, and the size of the orifice in the nozzle will all govern the ultimate gallonage delivered from the nozzle.

Strainers

These are screens made of various materials, preferably stainless steel, which usually are 50 mesh or coarser. They are located at the filling opening, suction line to the pump and at the nozzle tip. Their presence is to prevent any foreign substance access to the spraying system. On the contrary, should they become clogged, they can vitally affect any portion of the delivery system. Routine cleaning is imperative not only for the sprayers to function properly, but is extremely important if the calibrated delivery system is to be accurate

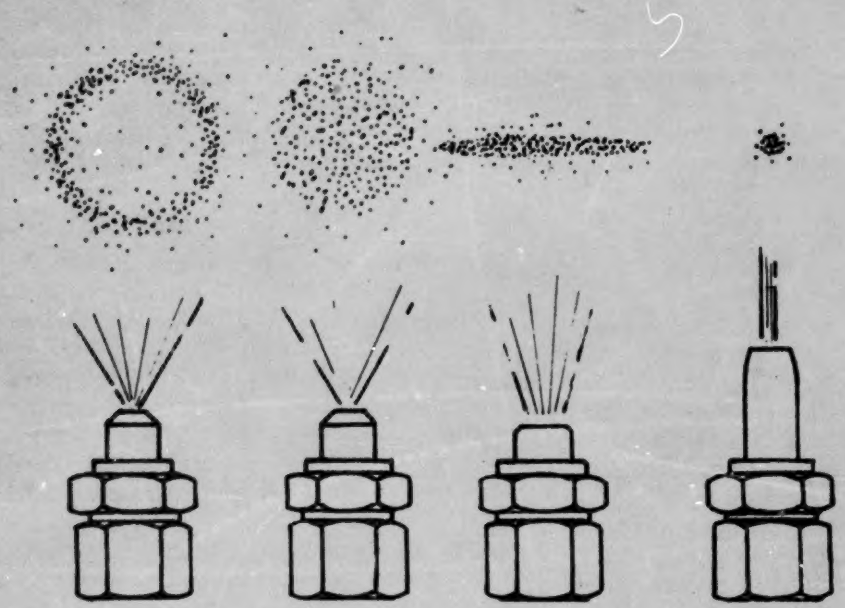

Figure 111 – Diagrammatic Presentation of Nozzles and Spray Patterns.
Left to Right: Hollow Cone, Solid Cone, Flat Fan, Pin Stream

Valves

There are many types of valves with some being extremely sophisticated. Their purpose is to shut off the flow of the liquid. Consequently, they are strategically located to be most effective in the advent of an emergency or in the normal function of the shutting off of the supply of liquid. Some have a time consuming screw type shutoff; others, either because of emergency or specific use, shut off instantly. Whichever type is used, frequent inspection to determine their proper functioning is important to guard against any leakage. This inspection is important with regard to maintaining pressures as well as preventing a potential hazard caused by unnecessary drippage.

Pressure Regulators

As the name implies, this unit controls the pressure of the liquid being delivered to the nozzle. As with many of the other parts, there are numerous types of regulators. Spring tension which is controlled by a hand-adjusted screw mechanism exerts pressure on the liquid as it flows through the regulator on its way to the nozzle. They can be operated from zero pressure to as high as 800 psi. The indicator or gauge for pressure is located adjacent to or is a component part of the regulator and, as indicated, records the pressure as pounds per square inch. In addition to establishing the pressure, a provision exists for the excess or overflow to bypass the regulator and return to the tank. In many sprayers this return line is located near the bottom of the tank and can be either the primary or secondary measure in the agitation of the spray material in the tank.

Agitators

This is a means by which the contents of a spray tank is mixed or agitated. The object is to keep the pesticide in continuous suspension so that it results in an even distribution of the material. In some formulations (wettable powders), mechanical is the only type of agitation that maintains suspension. In this method, a set of paddles is attached to a horizontally located shaft at the lower portion of the tank. Exteriorly, the shaft is connected to the power source. Bypass agitators are a frequently used method of agitation. This technique utilizes the overflow from the regulator to stir the contents of a tank. Obviously, if the nozzle or nozzles are shut off, this system is quite effective. However, if one is utilizing the full output of the pump, very little fluid is bypassing the regulator; consequently, there is very little agitation. Jet agitators are connected to the pressure side of the pump and a supply pipe placed horizontally at the bottom of the tank. The orifice size must be commensurate with the capacity of the pump so that the supply is adequate for it and the nozzle. In all forms of agitators, problems may arise due to the type of the formulation used.

Specialized sprayers utilizing electric or gasoline power which are small and are usually utilized in homes or confined spaces are referred to as space sprayers. They are normally used more with oil formulations than water because of the smaller droplet size generated. The capacity is usually only a few gallons. The droplet size can be extremely small so that it floats in the air for a considerable time or large droplets which allow them to settle quickly.

Gas Generating Sprayers

There are essentially 2 types of gas generated sprayers, floating piston type and the very common aerosol spray can (Fig. 112). In the former, a cylinder with a floating piston having nitrogen gas is in one end of the cylinder and the pesticide, which is pumped under pressures of 300 to 1000 pounds per square inch, is in the opposite end. This compresses the piston against the nitrogen and forces the insecticide through a high pressure hose into a very fine orificed nozzle. Although it can be used independently for a limited time, it depends upon a pump situated reasonably close to the job for reloading.

Figure 112 – Aerosol Spray Can

Aerosol can dispersal of pesticides, although not new, has been very popular both with the public and pest control operators. Their range in capacity, from 6 ounces to 30 gallons, has made them very popular. The small sizes have push type release nozzles while those with a capacity of 5 pounds and up have a mechanical shut-off nozzle. They also come, particularly in the sizes less than 5 pounds, in disposable type containers. Their construction is very simple, consisting of a container in which designated amounts of pesticide and freon are placed. As long as the temperature in the vicinity of the area the material is to be dispersed is warm, the freon will propel the pesticide out of the orifice. The tube leading to the orifice is usually placed such that it reaches the bottom of the container. Aerosol application is generally confined to enclosed areas since the problem of drift is ever present.

GRANULAR APPLICATORS

As the name implies, this is an applicator for the application of granular formulations. Essentially, these are small hopper type units with an orifice for the material to drop onto the crank operated spinning disc which throws the material over a 15 to 20 foot swath. Also, the same equipment is available in gasoline or power take-off drives which employ the same above principle only on a larger scale. Granules are ready for immediate application. Granular applicators, except in the case of weed control, are rarely used in the structural pest control industry.

BRUSH APPLICATION

Brush application quite often is recommended on the label for use in areas where a wet application is desired, but care is to be exercised in preventing the movement of a pesticide to non-target areas. This technique is usually confined to application along baseboards, window sills and door thresholds.

FUMIGANT INJECTION

The only fumigant injection method which might be used by a structural pesticide applicator, other than these described in the section on Fumigation, is local spot injections for the control of drywood termites and wood boring beetles. This technique utilizes a small hand-held CO^2 pressurized applicator with a nozzle designed to penetrate into either the small emergence holes created by the insects or into specially drilled holes which open into the galleries. Usually some formulation of ethylene dibromide is used.

SPOT TREATMENT

Spot treatment is application to limited areas on which insects are likely to occur, but which will not be in contact with food or utensils and will not ordinarily be in contact with workers. These areas may occur on floors, walls and bases or outsides of equipment. For this purpose a "spot" shall not exceed 2 square feet.

Crack and Crevice Treatment

Crack and crevice treatment is the application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter a building. Such openings commonly occur in expansion joints, between different elements of construction, and between equipment and floors. These openings may lead to voids such as hollow walls, equipment legs and bases, conduits, motor housings or switch boxes.

U.L.V.

Ultra-low volume application, as defined in agricultrual application, is the spraying of undiluted pesticides in small volume, usually at rates of 1/2 gallon per acre or less. This tern when used in structural applications has a somewhat different meaning. It is sometimes referred to as U.L.D. or ultra-low dosage.

The principle of U.L.V. application is the dispensing of a low volume of insecticides over a relatively large area. This is accomplished by breaking the insecticides down into tiny particles. Maintaining the particle size is very important.

SOIL INJECTION

This technique employs a long hollow, pointed probe connected to a spray rig and a shut-off valve at the top of the injector. It is useful in placing termiticides deep into the soil around the exterior foundation.

SUB-SLAB INJECTION

This technique is used for treating soil beneath slabs for the control of subterranean termites. This is one of the most useful tools developed for this type work. The sub-slab injector can be adopted to both 1/2-inch and 3/4-inch holes drilled in slab. It has some disadvantages. Among them is the inability to always know exactly the direction of the flow beneath the slab.

Pest	Application Technique
Ants – Inside	Manual spraying to interrupt trails. Brush application. Manual dusting.
Ants – Outside	Power spraying yard and crawl space. Power dusting can be used in crawl space and attics. Thoroughly soak nest of mound building species. Prepared baits can be used.
Cockroaches – Food Areas	Crack and Crevice Specially equipped plastic tubes at nozzle end or aerosol crack and crevice applicators are preferred. Keep the tip moving approximately 1 foot per second Do not allow solution to remain on surface surrounding the crack. If dust is used be sure that all dust is brushed into cracks and crevices.
Cockroaches – Non-food areas	Manual spraying with fine mist nozzle for residual treatment. Pinpoint nozzle for nesting places. It may be necessary to power spray or power dust for Oriental and American cockroaches as they often infest crawl spaces and basements. It is important that the proper distance from nozzle to surface be maintained to prevent excessive fallout. Also the speed that the nozzle moves is important in order to ensure proper amount of solution being applied in the right place.

READ THE LABEL

Pest	Application Technique
Scorpions	Power spraying with residual insecticide around foundation and entries into house. Manual spraying or brush application around moldings, baseboards and plumbing.
Bed Bugs	Manual spraying with fine fan spray for mattresses and pinpoint spray for cracks, moldings, bed springs and other hiding places.
Spiders	Door, thresholds, window sills and other entries can be sprayed manually with residual pesticide. Power spraying with wettable powders or emulsions in yards.
Ticks	Power spraying or power dusting with residual insecticide in yards, crawl spaces and dog runs. Manual spraying with close attention to baseboards, window casings and under rugs. Sometimes necessary to treat upholstered furniture with fine spray.

READ THE LABEL

Pest	Application technique
Fleas – Inside	Manual spraying with fine spray around walls, rugs and upholstered furniture. Hand-held misting machines can be used but need only be directed downward. Fleas are seldom found higher than 3 feet in living quarters.
Fleas – Outside	Power spraying in yards and dog runs. Power spraying or power dusting in crawl spaces.
Bees, Wasps, Hornets, and Yellow Jackets	Blowing of dust with either a good hand-cranked duster or power duster directly into nest. Some baits are effective against yellow jackets.

READ THE LABEL

Pest	Application technique
Clothes Moths, Carpet Beetles and Carpet Moths	Manual spraying with coarse, wet spray pattern. Residual pesticides with oil or water emulsions can be used. Do not soak rugs with oil-based sprays. Sufficient pressure and volume must be used to drive solution into fiber of rugs and upholstery to reach infestation. Pay special attention to areas next to walls.
Stored Food Pests	Manual spraying with residual insecticide in cabinets and shelves. Fine pinpoint spray in cracks. Clean up after drying or put shelf paper down before replacing utensils. Fogging or U.L.V. can be used in storage areas or warehouses. If food is present, use contact insecticides only, avoid contamination.

READ THE LABEL

Pest	Application Technique
Flies	Space Fogging with knock down spray will help in diminishing the adult population but does not figure as effective measure of control. Power spraying of harborages will prevent breeding to some extent. Fly strips can be used in patios or Bar-B-Que areas. Larvacides applied to infested areas around dairies, chickens or horses. Sanitation is the key to fly control.
Sow Bugs, Pill Bugs, Springtails, Earwigs, Crickets, Millipedes and Centipedes	Power spraying of all harborages with low pressure-high volume.

READ THE LABEL

Pest	Application Technique
Silverfish	Manual spraying with pinpoint pattern applied to cracks, behind drawers, molding with residual insecticide. Power dusting of attics may be necessary.
Clover Mites	Power spray a band around the exterior of house extending into the yard at least 10 feet and up the walls to window height. Manual spray inside, around edges of windows and doors.
Snails and Slugs	Baits scattered on moist ground. Remove dead snails and repeat baiting until control is established.

READ THE LABEL

Pest	Application Technique
Subterranean Termites in Crawl Space	Power spraying with low pressure-high volume, using persistant termiticide solution. Apply at rate of 1 gallon per 10 square feet of soil area. Apply 2 gallons per 5 lineal feet of foundation walls. If foundation is over 15 to 18 inches deep, apply 4 gallons per 5 lineal feet. Use subsoil injector outside foundation. Do not apply below the top of the footing.
Subterranean Termites in Slab Construction	Sub-slab injection in areas where termites appear.

READ THE LABEL

Pest	Application Technique
Drywood Termites (Localized Infestation)	Inject liquid fumigant in emergence holes or holes drilled to allow entry into galleries.
Drywood Termites (General Infestation Extending into Walls)	Complete fumigation with lethal fumigant (see section on Fumigation).
Wood Boring Beetle (Localized Infestation)	Inject liquid fumigant into emergence holes. Some beetles can controlled by spraying surface wood to a point of runoff. This may require repeated applications.
Carpenter Ants	Locate the nest and manually treat with residual insecticide.

READ THE LABEL

REFERENCES

Brooks, Joe E. and Peck, Thomas D. 1969. Community Pest and Related Vector Control. Pest Control Operators of California.

Truman, Lee C. and Butts, William L. 1967. Scientific Guide to Pest Control Operations.

Dow Chemical Company. 1966. How to Fumigate Buildings with Dow Methyl Bromide.

Pest Control Magazine. 1971. Refinements in U.L.V. Vol. 41-No. 8.

LEARNING AT HOME

Review Questions – Section 7

1. Name 5 different types of application equipment:
   a ________
   b ________
   c ________
   d ________
   e ________
2. What conditions should be considered when selecting a spray hose:
   a ________
   b ________
   c ________
3. Name 3 common spray patterns:
   a ________
   b ________
   c ________
4. Mechanical agitators are more important for what type of pesticide: ________
5. The greatest hazard in applying a dust is:
   ____
6. In the definition of "spot treatment" a "spot" shall not exceed: ________.
7. Name 4 different methods of applying pesticides:
   1. ________
   2. ________
   3. ________
   4. ________
8. In injecting termiticide in the soil along the foundation, it should not be injected below
   ____
   ____
9. What type of application equipment is most widely used for effective cockroach clean out calls in dwellings: ________
   ____
10. ULV means what: ________
    ____
11. The crack and crevice technique is usually employed where: ________
    ____
12. When using a hand-held pressurized sprayer, name 2 important things to do during application to ensure that the proper amount of solution is being applied in the right places:
    1. ________
    2. ________
13. Which species of cockroaches infesting a house may call for spraying or dusting the sub-area: ________
    ____
14. When spraying a rug for carpet beetles, particular attention should be paid to:
    ____
15. If foundation is over 15 to 18 inches deep, at what rate should pesticide be applied along foundation: ________
    ____

OUTSIDE ASSIGNMENTS

1. Obtain pictures or take some of your own of any equipment you may use or some of the equipment you have studied in this Section. Paste up as many pages as necessary to include these pictures. Leave a space above or below each picture for description, calibration, instructions for use and maintenance. Enter these in your notebook.

2. Construct a Table similar to the one in this Section. For each pest commonly encountered, list all pesticides available along with dilution rates shown on label that are ordinarily used for the control of these pests. This is good material for your notebook and provides a quick reference.

FUMIGATION

Kenneth Gordon
Gordon Termite Control
Rosemead, California

INTRODUCTION

Fumigation can be defined as the use of gaseous poisons to kill insects or other pests. Their application is generally limited to plants or products in tight enclosures or those which can be enclosed in relatively gas tight tents or wrappings or to soil. These categories obviously encompass a wide range of commodities and conditions. Many of these are beyond the scope of this text and will not be presented. The intent of this section is to discuss the common fumigants used in the pest control industry and to alert the reader to the methods, materials and techniques used in structural fumigation.

COMMON FUMIGANTS

Methyl Bromide

Methyl bromide is a colorless, odorless gas at room temperature which is approximately 3.3 times as heavy as air. It is slightly soluable in water and is nonflammable. In fact it has been used as a fire extinguishing agent. Methyl bromide comes in pressurized cylinders (hence in liquid form) and when used in structural fumigation is usually dispensed through a heat exchanger. Its vapors can be detected with a halide gas detector, and concentration can be measured with a conventional thermal conductivity gas analyzer. It has been successully used in structural, warehouse and mill fumigations. Methyl bromide has good penetrating qualities and will kill insects in all stages, including adults, larvae, pupae and eggs. Dosages for insect control is usually 2 to 3 pounds per thousand cubic feet. For rodents use 1/4 pound per 1,000 cubic feet for 6 hours exposure.

Following is a list of items to be removed before fumigating with methyl bromide. This is only a partial list. When in doubt, pre-test a portion of material to be fumigated.

1. Iodized salt.
2. Full fat soya flour.
3. Some soap powders, baking sodas and salt blocks used for cattle.
4. Sponge rubber.
5. Foam rubber
6. Any form of reclaimed rubber.
7. Furs, horsehair and feather pillows.
8. White kid leather or any leather tanned with sulfur process and silver polishing papers.
9. Angora woolens and hand knit woolens.
10. Some cinder blocks.
11. Charcoal materials.
12. Seeds, bulbs or living plants.
13. Pets

Unfortunately, from a toxicological viewpoint, methyl bromide is highly toxic to man and animals. Because of its high toxicity, high volatility, and lack of warning properties such as odor and irritation, it is quite hazardous to handle. Handling and use, therefore, must be carried out in such a way that exposure does not occur or is limited in intensity to levels known to be safe. The addition of chloropicrin as a warning agent is required by regulation in some usages and is prohibited in others, particularly if food is involved.

The initial symptoms after excessive exposure to methyl bromide are usually headaches, dizziness, nausea, vomiting, weakness and collapse. These symptoms may be followed in from 2 to 48 hours by the more serious effect, lung edema. If death results, it is likely to be from this cause. If the person survives the lung edema, complete recovery is to be expected. The typical symptoms resulting from excessive chronic (repeated) exposures usually include blurred vision, staggering gait, mental imbalance, and psychosis. Here again, if injurious exposure isn't excessive, recovery is complete but may take an appreciable period of time.

The most recent threshold limit value for methyl bromide as specified by the American Conference of Governmental Industrial Hygienists is a ceiling of 20 parts per million. This means that in all probability, persons can tolerate up to 20 ppm, but no more, of methyl bromide 7 to 8 hours a day, 5 days a week, for a prolonged period of time without adverse effects. If the daily periods of exposure are shortened substantially or the frequency of exposure is lessened, the amount in the air which can be tolerated will be greater.

It is well known that blood bromide levels rise as a result of either acute or chronic exposures to methyl bromide and this provides one means of diagnosis of suspected cases of poisoning. Blood bromide levels can rise from many other causes, so one has to be very careful in interpreting blood bromide levels. A normal person who is not exposed to bromides of any sort, either swallowed or inhaled, will have a blood bromide concentration of less than 1 milligram percent (1 milligram of bromide per 100 millilieters of blood). If a blood level in the range of 5 milligrams percent were found, some exposure to bromine-containing compounds has definitely occurred. This should be a warning signal and should indicate that the source of this bromide should be determined. If it is due to inhalation of methyl bromide then the techniques employed in fumigation are faulty. If it can be associated with the ingestion of bromine-containing drugs, then this value is of no significance in evaluating exposure. Blood bromide levels in the neighborhood of 10 milligrams percent definitely attributable to methyl bromide exposure are approaching a serious level. If these levels rise to 15 or more milligrams percent, it is quite likely that serious symptoms of methyl bromide poisoning will appear.

Bromide concentrations derived from the administration of drugs can result in blood bromide concentrations several times these without any adverse effect. In fact, blood concentrations have to exceed 100 milligrams percent before evidence of a condition known as bromism becomes apparent in most individuals. Certainly blood levels significantly less than 100 milligrams percent present no problem when the bromide is derived from such materials. Thus it can be seen that it is extremely important and absolutely essential that the source of bromide in the blood be ascertained before its significance can be evaluated.

It is suggested that men who routinely are employing this type of fumigant be checked at least once a month to determine their blood bromide levels. If analysis reveals that the bromide content of blood from these individuals is low, that is, definitely less than 5 milligrams percent, it is an indication that the men are exercising a reasonable degree of care in their work. If they are above this level, it indicates that an investigation should be conducted as to the source. Such information not only will serve as a protection to the individual and give him reassurance that he has not received excessive exposure, but also it will give the employer reassurance that his employee has been operating in a safe manner or indicate that more care must be exercised in future operations. If a person should become ill or have reason to suspect excessive exposure and has been handling methyl bromide, it would be well to have a blood sample taken promptly for bromide determinations. If the bromide level is found to be excessive, there is reason for concern. If it is not, then one can rest assured that the person has not had an excessive exposure to methyl bromide.

Methyl bromide, if confined to the skin beneath a covering such as tight clothing or shoes, is capable of causing a burn usually characterized by the formation of a large blister. This can also occur from wearing bandages or adhesive tape when exposure is to methyl bromide vapors. In such cases, the vapor is absorbed in the adhesive or bandages thus resulting in prolonged contact with the skin. Therefore, it is recommended that no bandages be worn when handling methyl bromide and that precautions be taken to avoid contact with the liquid. Methyl bromide is poorly absorbed through the skin and hence under practical operating conditions does not present a hazard of systemic effects from exposure on the skin.

Vikane (Sulfuryl Fluoride)

Vikane® fumigant is a compressed gas with a wide range of biological activity, containing sulfuryl fluoride as its active ingredient. It is practically insoluble in water, stable to heat and non-flammable in atmospheric concentrations. It possesses remarkable penetrating powers and has a boiling point lower than any other fumigant. Due to its high vapor pressure, it diffuses rapidly. It requires no special equipment for dispensing, is relatively unreactive to household effects and to date has shown no odors or staining when used under normal conditions. No corrosion has appeared in fumigated materials.

Its presence is detected with the Davis Detector. Thermal conductivity units are used to measure concentration. Manufacturers provide instrumentation to calculate tailored dosages.

Following is a list of items to be removed before fumigation with Vikane:

1. People.
2. Plants.
3. Pets.
4. Food and medicinals not sealed can be removed or placed in polyethylene bags and closed with tape.

The high volatility of Vikane precludes adverse effects upon the skin except for possible "frostbite" should a container be discharged directly on the person. Becuase of its high vapor toxicity, high volatility, and lack of warning properties, such as odor and irritation, handling and use must be carried out in such a way that exposure does not occur or is carefully limited to concentration known to be safe. The use of chloropicrin as a warning agent prior to fumigation is generally recommended in all fumigations with sulfuryl fluoride and is required by regulation in many areas. Since sulfuryl fluoride has a very rapid diffusion rate, aeration of structures is rapid and the hazard to occupants after appropriate aeration is nil.

Based upon extensive studies on animals, sulfuryl fluoride is one half to one third as acutely toxic as is methyl bromide. Excessive single exposures can result in tremors with subsequent severe convulsions. Recovery of surviving animals is generally rather rapid. Sulfuryl fluoride has been shown to have a rather high toxicity on repeated exposure. Kidney and lung injury can occur from excessive repeated exposure. The gas is not irritating to the eyes or skin, and it has been shown that undiluted sulfuryl flouride gas is not absorbed through the skin. The low solubility of sulfuryl fluoride in foodstuffs minimizes the likelihood of ingestion of toxic amounts. However, good practice requires that foods should be removed from the house prior to fumigation or else sealed in tight containers such as plastic bags or refrigerators.

Chloropicrin (Tear Gas)

Chloropicrin is often used as a warning agent in the odorless fumigants at the rate of 1 ounce per 15,000 cubic feet. It is also an effective fumigant in some situations. The primary toxic effect of chloropicrin to humans is irritation of the respiratory tract. An individual will probably not willfully tolerate concentrations which are acutely toxic.

Carbon Disulfide

Carbon disulfide is a colorless liquid which is highly volatile. It forms a heavy vapor that has an unpleasant odor. It is seldom used in the home but has some value in fumigating ant hills and grain bins. When used alone, it presents a very serious hazard of fire because of its low ignition point. Most compositions are designed so as to minimize or eliminate the fire hazard. The principal toxicological hazard is from inhalation of vapor but the liquid material also presents a real hazard of skin irritation, particularly if exposure is frequently repeated. Absorption of toxic amounts through the skin from contact with the liquid can occur but the hazard would seem to be small unless exposure were severe and repeated. Excessive single exposures by inhalation may cause unusual fatigue, headaches, visual disturbances, nausea, vomiting, loss of memory and depression up to unconsciousness and death.

The most important effects of repeated sublethal exposures are neurological. These may be manifested in a variety of ways but coldness and heaviness of limbs, tenderness of nerve trunks, polyneuritis, loss of memory, and varying degrees of depressive psychosis are typical symptoms. Injury to the brain is the typical lesion observed upon microscopic examination of tissues. Although it has been generally accepted that vapor concentrations of carbon disulfide should be maintained below 20 ppm for prolonged and repeated exposure, recent observations on humans exposed for many years to carbon disulfide vapors in Italy suggest that 10 ppm would be more appropriate guide for control.

Hydrogen Cyanide

Hydrogen cyanide gas, at one time, was one of the most commonly used fumigants. However, this is one of the most toxic and hazardous fumigants. Because of its toxicity and the availability of superior chemicals, the use of this material has been prohibited in most states. The acute toxicity of hydrogen cyanide to man occurs very rapidly, and usually, if they do occur, there is a considerable finality associated with them. The action of hydrogen cyanide is primarily that of inhibiting certain body enzymes which have to do with oxygen transport. However, there have been a few reports of neurological abnormalities resulting from exposure to hydrogen cyanide. Death results from asphyxiation. The probability of chronic effects occurring is slight; the problem is to prevent exposure to acutely toxic amounts of the material. The concentration generally accepted as safe for repeated 8-hour exposures is 10 ppm. Hydrogen cyanide can be readily absorbed through the intact skin in lethal amounts as a result of contact with liquid material or the gas. It is velieved that a sweating person is more vulnerable because the gas dissolves in the sweat from which it is absorbed more readily.

Acrylonitrile

Acrylonitrile is a clear liquid and as a gas is inflammable in high concentrations. When mixed with carbon tetrachloride, it has been used as a spot fumigant in elevator boots. The acute toxicity to man appear to be very similar to those of hydrogen cyanide although the material is not as toxic as hydrogen cyanide. Acrylonitrile is metabolized in the body, but slowly, to hydrogen cyanide. The material may be absorbed either through the lungs or through the skin, and if exposures are excessive, high concentrations of cyanide result and the effects are essentially the same as with HCN. Symptoms include increased respiration rate, salivation, nausea, excitability, vasodilation, cyanosis, and terminal coma in critical cases. For repeated daily inhalation, a vapor concentration of 20 ppm is considered safe.

Ethylene Dichloride

Ethylene dichloride is normally used in combination with carbon tetrachloride for the control of insects in grain. It is usually mixed 1 part of carbon tetrachloride to 3 parts ethylene dichloride and is slow to vaporize and requires long exposure periods.

It is rarely used by itself because of its flammability. Ethylene dichloride is somewhat more toxic acutely to animals than is carbon tetrachloride. Experience indicates, however, that most people will not tolerate or will become nauseated by sublethal concentrations. It is believed that for this reason, there have been few, if any, fatalities or even serious illnesses due to ethylene dichloride. Acutely, it is a central nervous system depressant and lung irritant. Chronically, ethylene dichloride is a safer material than carbon tectrachloride. The ACGIH Threshold Limit value for repeated 8-hour exposures has been established at 50 ppm. It has the ability to cause injury to the liver and kidney from either excessive single or repeated exposures.

Ethylene Dibromide

Ethylene dibromide is a colorless liquid used as a constituent of grain fumigants and a soil fumigant for subterranean termites. It is nonflammable and its vapors are non-explosive. It has good penetrating qualities and is toxic to grain insects.

Ethylene dibromide is actually somewhat more toxic than methyl bromide. The fact that it is a liquid under ordinary circumstances and that it has a distinct odor that is detectable at a concentration of 25 ppm makes it considerably less hazardous to handle than methyl bromide. The ACGIH Threshold Limit value for repeated 8-hour exposures for ethylene dibromide is 25 ppm as a ceiling value. Ethylene dibromide, as well as methyl bromide, is a skin irritant. Spillage on the shoes or on the clothing where the fabric is in close contact with the skin will almost invariably result in the formation of huge blisters unless it is promptly and thoroughly removed. The vapor of ethylene dibromide is not absorbed through the skin to any significant degree, but liquid ethylene dibromide can be absorbed through the skin in toxic amounts.

Ethylene Oxide

This material is a colorless liquid which will vaporize at room temperature. It is shipped in steel cylinders and is often used in combination with carbon dioxide due to its vapors being flammable. It is used at the rate of one part ethylene oxide to 9 parts carbon dioxide to form a commercial product known as carboxide. Ethylene oxide is popular in vacuum chamber fumigation.

Because of the flammability and chemical reactivity of this material, the fumigator must be familiar with the special techniques required for handling without accident in addition to being aware of the toxicological hazards. The primary toxic hazard of ethylene oxide is that of inhalation of the vapors but skin and eye contact can also be injurious. If small amounts of liquid are allowed to evaporate freely over the skin, irritation does not appear to occur.

Methylene Chloride

Methylene chloride is one of the least toxic of the chlorinated hydrocarbons. If allowed to evaporate from the skin, it produces only a mild tingling sensation. If confined on the skin beneath bandages, inside of shoes, or other clothing, it can cause considerable discomfort and irritation. It is not absorbed through the skin in toxic amounts. High concentrations of the material can be anesthetic but the concentration must be several thousand parts per million before the effects become pronounced. The material possesses very little ability to cause liver injury. Animals have been exposed repeatedly for 7 hours per day for months to 5000 ppm with only questionable adverse effects. A threshold limit value of 500 ppm is recommended for repeated 7- to 8-hour daily exposures. Acute exposures should be limited to those which do not cause anesthetic effects.

Naphthalene

Naphthalene is familiar as moth balls and moth crystals. It is a rather weak fumigant and repellent. Injury is not likely to occur from inhalation of naphthalene unless the material is handled at high temperatures. Skin and eye contact do not present a serious problem with naphthalene but repeated ingestion can result in cataracts.

Paradichlorobenzene

Paradichlorobenzene is used as a weak fumigant and moth repellent. The hazard from inhalation of vapor, eye or skin contact, or ingestion in this usage is not significant. Ingestion of large quantities could, of course, be injurious. Industrial experience has shown that for short periods, the warning properties of the vapor are adequate to prevent overexposure.

Perchloroethylene

Perchloroethylene (tetrachloroethylene) is used in small amounts as a commodity fumigant. It is a good solvent and hence may cause dryness and cracking of the skin if exposure is prolonged or frequently repeated. The liquid is only slightly irritating to the skin and eyes but may cause some pain if it is splashed in the eye. The vapors can cause incoordination as well as more pronounced anesthetic effects depending upon the severity of the exposure. Repeated exposure to excessive concentrations can cause liver injury. It is good practice to limit exposure to a maximum level of 200 ppm with the average at no more than 100 ppm.

Propylene Oxide

Propylene oxide when mixed with carbon dioxide is occasionally used in commodity fumigation. This chemical presents chemical, toxicological and flammability hazards comparable to but less than those of ethylene oxide.

Carbon Tetrachloride

Carbon tetrachloride is an excellent solvent. It is used as a flame depressant when mixed with other fumigants but due to its toxicity to man in both liquid and vapor form is rarely used as a household fumigant.

Phosphine, Aluminum Phosphide (Phostoxin)

Aluminum phosphide, a solid, is formulated in tablets and pellets which are distributed throughout the commodity to be fumigated. These tablets slowly react with moisture to release phosphine gas (PH_3) and a "protective gas."

Phosphine is highly toxic for both single and repeated exposures. The effects of single exposure to phosphine are a feeling of coldness, pain in the diaphragm, nausea and vomiting. Shortness of breath, weakness, dizziness, bronchitis, edema, convulsions, and death can occur if the exposure is excessive. The chronic effects of phosphine are reportedly the same as those of phosphorous: gastro-intestinal upset, jaundice, and nausea. The currently accepted threshold limit value for repeated 7- to 8-hour daily exposure to phosphine is 0.3 ppm. Rubber gloves are recommended for handling the pelleted formulations.

SAFE HANDLING OF FUMIGANTS

All fumigants have appreciable toxicity towards humans and animals, but since they differ considerably, it is difficult to write general instructions for fumigating procedures. In all cases, the fumigator must read and understand the manufacturer's label, and use only as registered thereon. If the instructions on the label are not adequate, the fumigator should obtain more detailed instructions from the supplier or manufacturer. The supplier and manufacturer are obligated to provide adequate information to the user as to toxicity and handling and may be expected to do so if requested.

The symptoms described as resulting from excessive exposure to most of the fumigants in this article are nonspecific in that they are observed in many different illnesses. The diagnosis of poisoning due to a fumigant as opposed to a diagnosis of illness resulting from natural causes can be made only by a physician who is capable of objective consideration of all the facts that can be developed from an examination of a patient and a consideration of possible exposure. This objectivity is important. Self-diagnosis is dangerous even for the well-trained. The best policy is always to report any illness to the physician.

Information concerning the effects of a chemical as well as the symptoms to be expected should be known to the local physician prior to the use of the fumigant. This kind of information can be obtained for the doctor from the supplier of the fumigant. The supervisor of the fumigation should make it a point to get the information from the supplier and transmit it to his physician before using the material. The advantages of this are that it allows the physician time to examine the literature prior to any difficulty and to procure needed supplies.

Safety Equipment

Every person who is working with fumigant materials should be well informed regarding the hazard of the materials, the appropriate protective devices to be used with each and the limitations of such devices. A choice of a gas mask depends upon the material to which the person is likely to be exposed, the intensity of exposure anticipated and the availability of an adequate oxygen or air supply. Small respirators equipped with cartridge-type canisters are effective in the same way as full-face masks but the capacities are much smaller and they give no protection to the eyes where irritants or lacrymators are encountered. An ordinary full-face gas mask with a suitable standard or large-size canister is effective against vapor concentrations up to 2% by volume in air. The duration of the use of a canister must not exceed 20 minutes. Both the respirator and the gas mask can be used only where the oxygen content of the air is not depleted to less than 16%.

A self-contained breathing apparatus is by far the most dependable protection against toxic vapors. This equipment utilizes a tank of compressed air or a special canister in which oxygen is generated during usage. This self-contained equipment should be used if there is any possibility that vapor concentrations are in excess of 2% or if the oxygen content of the air may be too low. It is further evident that any person entering a pit or tank must also wear a safety belt and a rope and have one or more persons remain outside to pull him out in case of accident. There must also be a self-contained breathing apparatus with the watcher. Persons should never work alone in any hazardous operation.

The choice of a canister to be used with a full-face mask or a respirator depends upon the toxicant involved. An organic vapor canister is designed to provide protection against such materials as methyl bromide, ethylene dibromide, carbon tetrachloride, ethylene dichloride, chloropicrin, carbon disulfide, and similar substances within the limitations mentioned previously. For protection against sulfur dioxide, an acid gas canister must be used. For acrylonitrile, a canister designed for both organic vapors and acid gases is recommended. For protection against hydrogen cyanide, phosphine and sulfuryl fluoride, special canisters must be used. Read the instructions on the fumigant label. In all cases, the recommendations of the manufacturers of the fumigants, canisters and masks should be followed.

It is the responsibility of the person in charge of fumigations to see that an adequate supply of canisters and other necessary safety equipment is available before beginning a fumigation. This equipment should be inspected and tested prior to starting each fumication. All used canisters should be destroyed. The use of halide leak detectors, Thermal Conductivity Units (TCU) or other equipment for the detection and estimation of the concentrations of fumigants is recommended to prevent excess exposure.

DOSAGE CALCULATION FOR COMMONLY USED FUMIGANTS

Methyl Bromide

The methyl bromide label prescribes the amount of fumigant to be used at varying temperatures and volumes of the structure. Therefore it only becomes necessary to accurately compute the cubic content of space to be fumigated. Warning agents are usually included with methyl bromide; if not, the amount necessary is indicated on the label. The label will also prescribe the release rate, size of the releasing tube and the point of application. Gauges are available which will measure the amount of methyl bromide released at any point in time.

Vikane

In order to interpret the correct dosage for fumigation with Vikane, a Fumiguide "B" slide rule (Fig. 113) is extremely handy. A number of factors will influence the amount of Vikane to be used. Each of these conditions have been given a value factor on the slide rule. The conditions must be an estimate by the fumigator based on his expertise. Table 13 shows an example. By starting with the arrow and hairline slide both at 12 on the (HLT) scale, multiply each product by successive factors by first moving hairline slide to estimated condition, then moving center slide to line up with hairline slide. Do not return either slide to starting position until last product has been multiplied. After having moved first the hairline slide, then the arrow in alignment with hairline through all the estimated conditions, the arrow and hairline will both point to the half loss time on the top scale.

To convert the number of ounces per thousand cubic feet to pounds, turn the Fumiguide "B" over again and refer to the "A" and "B" scales at bottom. Place the arrow of "A" scale over ounces on "B" scale, then move the hairline slide to volume on "A" scale, and read number of pounds under hairline slide on "B" scale. Try working the problem on the following page. Your answer should read 7.3 half loss time.

A warning agent is always used with Vikane. It is not mixed with the fumigant due to the varying dosages of Vikane. The specific amount to be used is indicated on the label. Vikane dosage is best measured by placing cylinder on scales and after balancing the weight of the cylinder, adjust the scale to the desired amount and when this point is reached the scale will re-balance and valve can be closed (Fig. 114).

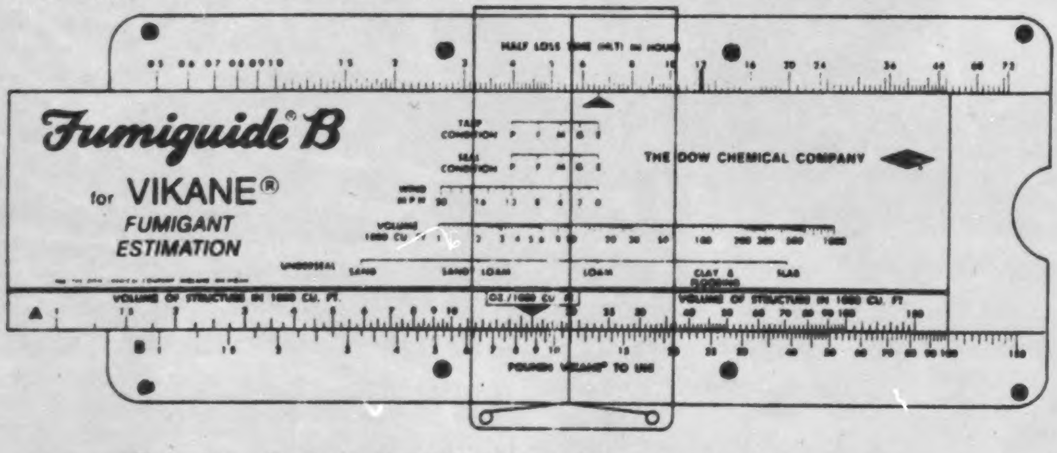

Figure 113 - Fumiguide "B" Slide Rule for Computing Dosage with Vikane.

Table 13. Example of Computation of Dosage of Vikane Used With Varying Factors

HLT Estimation

Influence	Estimated	Factor		Start with basic HLT of 12 hours, then multiply products by successive factors Example*
Tarp or Stucco Condition	Excellent	1.0		0.9 × 12 = 10.8 hours
	Good	0.9*		
	Medium	0.8		
	Fair	0.7		
	Poor	0.6		
Seal	Excellent	1.0		0.8 × 10.8 = 8.64 hours
Tarps	Good	0.9		
Tape	Medium	0.8*		
At Soil	Fair	0.7		
	Poor	0.6		
Soil	Slab	3.0		1.0 × 8.64 = 8.64 hours
	Clay	2.0		
	Loam	1.0*		
	Sandy Loam	0.5		
	Sand	0.25		
Volume (1,000 cu ft.)	1	0.4		1.2 × 8.64 = 10.4 hours
	3	0.6		
	8	0.8		
	16	1.0		
	27	1.2*		
	45	1.4		
	65	1.6		
	90	1.8		
	125	2.0		
	400	3.0		
	1000	4.0		
		Tarped	Sealed Masonry	
Wind (mph.)	0	1.0	1.00	0.7 × 10.4 = 7.3 hours
	1-2	0.9	0.95	
	3-5	0.8	0.90	
	6-9	0.7*	0.85	
	10-14	0.6	0.80	
	15-20	0.5	0.75	
	20	0.4	0.70	

Phostoxin

Because of the varied uses of Phostoxin, only a general outline of instructions can be included in this manual. The needs of the fumigator for a commodity fumigant will necessarily lead him to request special instruction from the manufacturer's agent or distributor for specific uses in fumigations where unusual conditions may be encountered.

Phosphine gas released by Phostoxin is highly toxic to all forms of animal life. Phosphine, also called hydrogen phosphide is a compound having 1 phosphorus atom and 3 hydrogen atoms, thus the formulat PH_3. The ingredients are:

Active ingredient	Aluminum Phosphide	55%
Inert ingredients	Amonium Carbamate	41%
Inert ingredients	Edible Paraffin	4%

The fumigating action is accomplished by the release of gaseous phosphine, through the decomposition of the tablets or pellets. This decomposition takes place in the following manner. The ammonium carbamate reacts with the heat in the atmosphere and starts the decomposition. This allows the moisture in the atmosphere to penetrate the aluminum phosphide which reacts to give off Phosphine

Phostoxin comes in 2 forms, tablets and pellets. The tablets are 4/5 of an inch in diameter and 1/5 of an inch thick, and after decomposition takes place, one gram of hydrogen phosphide is released. The pellets are spherical in shape and 3/8 of an inch in diameter. Upon complete decomposition, they release 0.2 gram of hydrogen phosphide. Phostoxin tablets are placed in aluminum flasks containing 1660 pellets each. As long as the containers are kept sealed, their active life is indefinite. However, they should be stored in a dry, cool place, and kept out of the reach of people other than trained personnel.

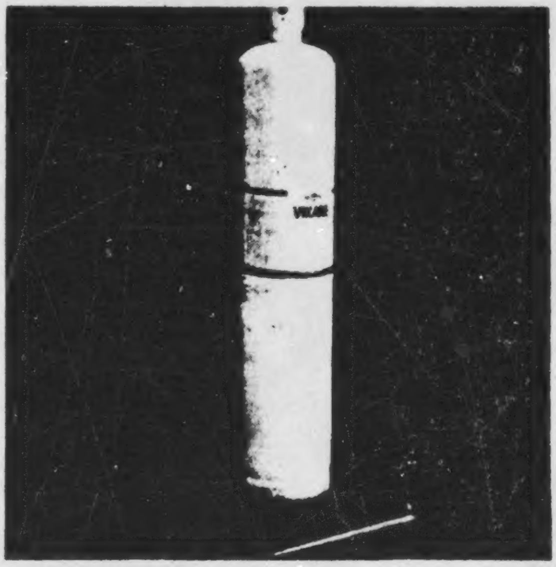

Figure 115 Vikane Dosage Can Best Be Measured By Placing Cylinder on Scale When Releasing the Toxicant.

Almost any dry commodity can be fumigated with Phostoxin, if placed under gastight tarps or placed in a gastight warehouse. Packaged commodities can be fumigated without opening, provided the packing is such that it is gas permeable. Phostoxin is not a space fumigant. The generation of the gas is slow and as the gas is dissipated, more gas is generated and toxic levels will remain. Therefore it is an excellent fumigant for flat storage and box car fumitation.

Hydrogen phosphide reacts with copper and copper compounds. Since many structures contain electrical wires, switches, and motors containing copper, precautions should be taken when fumigating within an enclosed structure to protect these items.

Phostoxin is effective against all forms of insect life, including adult, egg, larvae and pupa. All the insects that infest stored products, such as the orders Coleoptera and Lepidoptera can be controlled.

Dosage Rates

Dosage rates of phostoxin depends upon the tightness of the building or the tarps, the pests to be controlled and the temperature of the commodity to be fumigated. When fumigating products stored in bulk, or silos, the dosage is calculated per ton or per 1,000 bushels. When fumigating packed materials or commodities under tarps, the dosage is calculated on the basis of volume. In large steel silos or concrete bins, the dosage will be from 60 to 150 tablets per 1,000 bushels, again dependent upon type of pest, temperature and tightness of area fumigated. Loose grain fumigated under tarps, use 90 to 180 tablets per 1,000 bushels, or when using pellets, 270 to 540 pellets per 1,000 bushels.

When fumigating packed or bagged commodities under tarps, use 20 to 30 tablets per 1,000 cubic feet, or 120 to 225 pellets per 1,000 cubic feet. Structural fumigation, such as flour mills and warehouses, use 20 to 30 tablets per 1,000 cubic feet, or 100 to 150 pellets per 1,000 cubic feet. Tobacoo should not be fumigated with more than 20 to 40 tablets per 1,000 cubic feet.

Exposure Time

The exposure time depends upon the temperature inside the commodity, the humidity, the type of commodity and the type of insect to be controlled. An approximate exposure time would be:

50° to 59°F, using tablets – 5 days,
using pellets – 4 days
60° to 68°F, using tablets – 4 days,
using pellets – 3 days.
Over 68°F, using tablets – 3 days,
using pellets – 2 days.

Minimum exposure should not be less than 3 days for tablets and 2 days for pellets.

Very dry commodities such as grain under 10% moisture will require more exposure time. At lower temperatures, when fumigating for control of some of the resistant species of insect, such as rice weevil, maize weevil and grain weevil the exposure time may have to be extended up to 10 days or more. All mites are difficult to control by fumigation, therefore mite infested grain should be left under fumigation up to 10 days. For use of automatic dispensing equipment to be used in charging of silo bins, one should refer to manufacturer's bulletins.

FUMIGATION EQUIPMENT

Fumiscope (Model E, E-2, E-200)

Purpose and Principle of Operation

The Fumiscope is a portable instrument which will quantitatively measure the concentration of gases and vapors in air (Fig. 115). The instrument is calibrated for methyl bromide and will indicate directly the concentration of methyl bromide in dry air to an accuracy of 5 percent in concentration ranges from 0 to 100 ounzes of methyl bromide per 1000 cubic feet of dry air.

The Fumiscope uses a thermal conductivity cell to compare the thermal conductivity of a mixture of methyl bromide and dry air to that of pure dry air. This difference is converted into an electric current and is displayed on the meter. The Fumiscope contains a power supply for the operation of the cell and meter which operates on 115V ac. The Fumiscope also contains an electric pump and a gas flow rate meter so that air samples may be drawn through the thermal conductivity cell. The flow rate can be adjusted to a constant value regardless of the length or size of sampling tube by the flow adjust knob. A gas drying tube filled with an indicating dessicant is also included in the gas train for use or when extreme accuracy at low concentrations is required.

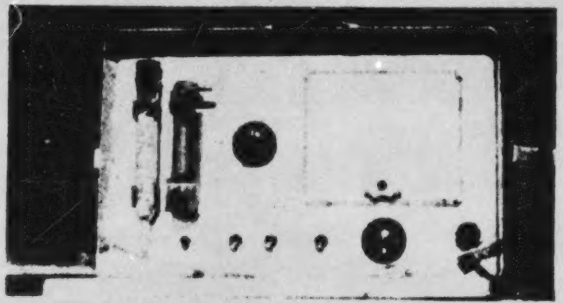

Figure 115 Fumiscope

Installation

The Fumiscope being a portable instrument, no installation other than a level place to set the instrument and a source of 115 volt ac power is required.

Controls

The Fumiscope is complete in one cabinet and requires no other auxiliary equipment. The various panel controls, etc., are listed:

Inlet – This hose connector is the gas inlet for the instrument and the sampling tubes may be connected to it directly or through the drying tube when it is required.

Drying Tubes – This glass drying tube contains a reversible indicating dessicant (Dririte). When the color of the Dririte is blue it is ready for use. When the color of all the Dririte in the tube becomes pink it is spent and must be regenerated. (See below for instructions and notes on use of drying tube.) The drying tube, when used is inserted in the gas sampling line between the sampling tube and the inlet connection. Indicating "Dririte" is made by the W. A. Hammon Dririte Company, Xenia, Ohio and is available from laboratory supply houses. Other drying agents may be used but some of them will absorb the methyl bromide as well as the moisture and thus will not give true readings. Silica gel as a drying agent should not be used for this reason.

Flow Rate Meter – This indicates the gas flow rate in cubic feet per hour and serves to indicate the flow of gas through the instrument so that it can be held constant regardless of minor flow resistances in the supply tubes. A flow rate of 1 cubic foot/hour is standard for this instrument.

If the meter pointer seems to be unstable and tend to wander over a short time period (seconds) the flow rate may be reduced below the 1 SCFH level for zeroing and measuring and then increased again to purge the sample lines.

Flow Rate Adjustment – This knob controls the flow rate by adjusting the pump. The flow rate may be increased by turning the knob counterclockwise. If this knob is turned too far CCW the pump will cease to operate properly and a great deal of noise will result. If the pump ceases to operate properly turn the knob all the way clockwise and then back it off to obtain the proper flow. If this does not correct the problem the pump may be clogged with dirt or some of the internal tube connections may have come loose.

Meter – The sensitive meter indicates the concentration of methyl bromide in air Due to the resistance of the measuring circuit the meter movement is highly damped and will frequently require slight tapping of the plastic cover to secure the proper reading.

Sensitivity Range Switch – Model E-2 and E-200

Model E-2: This switch changes the sensitivity of the Fumiscope so that the meter scale will read the concentration of either methyl bromide or Vikane directly from 0 to 100 ounces per 1000 cubic feet. Since the Fumiscope is twice as sensitive when the switch is in the Vikane position it may be used to read methyl bromide concentrations from 0 to 50 ounces. In effect this provides an expanded scale for measuring the lower concentrations of methyl bromide.

The proper use of a drying tube will be almost essential with the switch on the Vikane scale due to the sensitivity of the instrument being increased for moisture as well as methyl bromide and Vikane.

Model E-200: This switch allows methyl bromide to be measured in concentrations as high as 200 ounces per 1000 cubic feet as well as the standard 100 ounce range.

It has been found that this model is well suited for monitoring the useful concentrations of carboxide. On the 0 to 100 ounce scale one can read carboxide concentrations from 0 to 200 ounces and from 0 to 400 ounces. with the switch on the 200-ounce scale. Thus if the range switch was on the 200 ounce scale and you read 120 ounces on the meter scale you would have 240 ounces of carboxide.

Zero Adjustment Knob – The meter needle may be brought to zero as a pure air sample is being drawn through the instrument.

Line Switches – Separate line switches on both the pump and meter have been provided so that either may be operated separately as the occasion demands.

Fuse – The fuse is in the 115V ac. Replacement fuses are Little Fuse or Buss No. 3AG-½ amp.

Exhaust – A tube connection is provided at the top of the flow meter so that the exhaust gas from the instrument may be disposed of when the instrument is used in confined spaces. As the gas is exhausted at only 1 to 2 cubic feet per hour connections to this outlet should not be necessary in reasonably well ventilated areas.

Operation

Both line switches are turned on. After a warm-up period of 5 minutes, (15 minutes, if drying tubes are used), with the gas flow rate adjusted to 1 cubic foot per hour, the meter needle is set on zero. Several further adjustments within a few minutes may be necessary to secure a stable zero reading (especially when a drying tube is used). The instrument is now standardized and ready to measure the gas concentration when it is admitted to the area under fumigation.

Connect each sample tube from the area under fumigation in succession and mark the maximum reading obtained. Check the zero setting between each sample reading by letting the pump draw ambient air through the cell so as to make the pointer come back to zero. If the pointer does not come back to zero after a minute or so reset it to zero before taking the next sample reading and add or subtract the small difference from zero that existed from the previous sample reading. Frequently the zero setting will not have to be changed between sample readings.

Further zero adjustments should not be necessary if the drying tube is used, and should not be necessary without it if there is not a great change in humidity in the area under fumigation, with respect to the humidity of the ambient air used to zero the meter.

After the instrument has been used to measure methyl bromide concentrations the gas system should be purged of all residual methyl bromide by allowing the pump to draw clean air through the instrument for several minutes.

Maintenance of Fumiscope

Drying Tubes – If the drying tubes are to be used they must be changed as frequently as all of the dessicant becomes spent,(turns from blue to pink) as a spent drying tube is worse than none at all. When these tubes are refilled with fresh Dririte, that which is emptied should be saved in a bottle and regenerated when convenient. This will result in considerable saving of Dririte. Dririte is recommended since some of the other dessicants that are available will absorb methyl bromide as well as moisture and thus contribute to erratic readings.

Regeneration of Dririte – Place spent Dririte in a shallow dish or pan and heat in an oven to 300 to 400°F for 20 or 30 minutes and return to bottle containing fresh Dririte while still slightly warm. The Dririte may be dried while still in the tubes in the oven at the lower temperature for 30 to 40 minutes (remove rubber stoppers). The drying tubes should be kept closed when not in use.

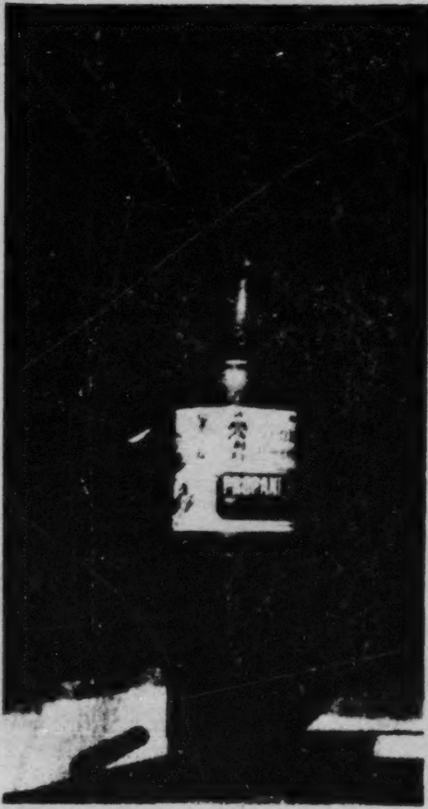

Figure 116 Halide Detector

Halid Detector

The Halide Detector consists of a propane torch in which the flame passes over a copper cone, causing the flame to change color in the presence of gas vapors in the halogen family of gases (Fig. 116). It is primarily used in structural fumigations to check for leaks during fumigation period, and to detect the presence of gas when aerating the structure. It has great value in performing a thorough and safe fumigation when using methyl bromide since the varying changes in color has been tabulated to show the amount of methyl bromide remaining, especially in the lower ranges.

Operating Instructions

Open the valve on propane cylinder, light the torch, and after the reaction plate becomes red hot, adjust the flame to a fine steady point where the top of flame just touches the reaction plate. It will remain red. Using the pick-up hose, pass the end of this hose close to the areas you wish to check, and note the change in color of the flame. It is important to remember that above the concentrations shown on Table , the flame could begin to smoke and become extinguished. At night the flame will have a bluish cast, but will

TROUBLESHOOTING

Indications	Cause and/or Remedy
Cannot zero meter pointer with knob.	If the meter will not zero after clean, dry air has been pumped through the instrument for several minutes, the sensitive filaments in the measuring cell are damaged and must be replaced. This damage is usually caused by water being drawn into the cell or corrosive or high molecular weight vapors in the sample stream being burned on the hot filaments.
Pointer wanders about the meter scale sometimes, cannot repeat readings always.	Sometimes a lower flow rate will improve or eliminate this problem. If the readings are good one time and way off the next there may be a loose electrical connection inside the case.
Pump does not produce enough flow or becomes noisy.	See section on Flow Adjust for a better understanding of the pump. Check sample tubes for restrictions or if there is no flow but pump does buzz one of the connections inside the case may have become broken. Remove panel and replace tube.
Readings are not as high as you might think they should be.	Check for leaks in sample tubing and connections. Connections held together with masking tape almost always leak. Pinch off sample tube and if the flow meter ball does not fall to the bottom there must be a leak.
When sample is being measured pointer goes up rapidly and then rises several more ounces over a period of 5 minutes. When the tube is disconnected the pointer falls rapidly to 5 or so ounces and then falls the remainder over a period of 5 minutes or so.	There is higher humidity in the area under fumigation than the ambient air. Either use a drying tube or correct the readings fro this difference by subtraction.

still react, and can be easily read. Table 14 indicates the amounts of methyl bromide in relation to color of the flame. Remember to keep the flame away from combustible materials.

Davis Detector

Although Vikane is rapidly cleared from a building under normal conditions, to assure returning occupants there will be no hazardous residue remaining, the Davis Detector Kit should be used (Fig. 117). Results of studies have led to the conclusion that concentrations of Vikane should be reduced to at least 10 parts per million before allowing reoccupancy. This kit is a small electric furnace that combusts Vikane to gases that can be measured by a change in color in the sampling tube. Directions accompany the kit and should be closely followed to obtain the best results.

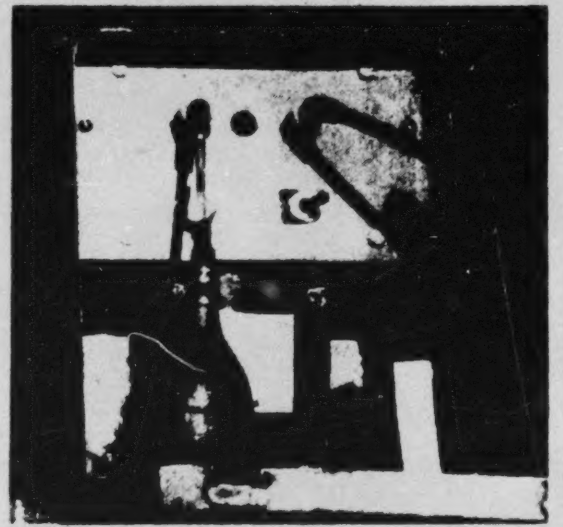

Figure 117 Davis Detector

Table 14. Detection of Methyl Bromide

The following tabulation gives the approximate methyl bromide concentration associated with color intensity in the flame of a Halide Leak Detector.

Parts Per Million	Pounds Per Mcf.	Flame Color
0	0	No Color
25	0.00625	Faint Green
50	0.0125	Moderate Green
125	0.031	Green
250	0.0625	Strong Green
500	0.125	Green-Blue
800	0.20	Strong Blue–Green
1000	0.25	Blue

Phosphine Detection Device

A simple squeeze bulb apparatus is available for measuring concentrations of Phosphine. This equipment is used to draw pre-measured quantities of atmosphere through detection tubes which initiate a color change to indicate the gas concentration parts per million, (PPM). Two types of tubes are available. One type will detect Phosphine up to 1,000 PPM, with graduations of 100 PPM. This tube is used to determine the concentration during different time periods of a fumigation. The other type of tube can measure presence of gas to 10 PPM with graduations of 0.1, 0.5, 1.0, 2.0, 5.0, 7.5 and 10 PPM. This type is usually employed as a safety device for determining presence of gas at very low concentrations. The threshold limits for Phosphine is covered in Section on Toxicological Consideration.

Circulation Fans

Two types of fans can be used to circulate fumigant vapors in a structure. One is of the axial type, and the other is the squirrel cage type (Fig. 118). Axial type fans will move more air than squirrel cage blowers, since the amount of air moved is controlled by the length and pitch of blades. Therefore, less current is drawn by the axial type for proportionate results. However, they are bulky, and difficult to transport and care for. The small squirrel cage type blowers are excellent for continuous circulation. Wherever the house current will allow it, without blowing fuses, larger fans of the squirrel cage type, operating at a higher RPM can be used to establish equilibrium. It has been established that without forced circulation there will be a rapid flow of gas to the lower portions of a structure immediately upon introduction of the fumigant. In fact, if the bottom seal is poor, the rate of loss would be greater than the upward dispersal of the vapors. It therefore becomes necessary to use forced circulation to obtain good diffusion of the fumigant with the atmosphere of the fumigated space. By use of forced circulation, the gas will be evenly distributed, resulting in an earlier equilibrium (equal mixing of the gas and atmosphere at all levels). It is suggested that a fan of larger capacity, equipped with a timer, be used for no less than one hour after introduction of fumigant, and smaller fans with a capacity of 300 to 400 cubic feet per minute, be placed in several locations to maintain continuous circulation.

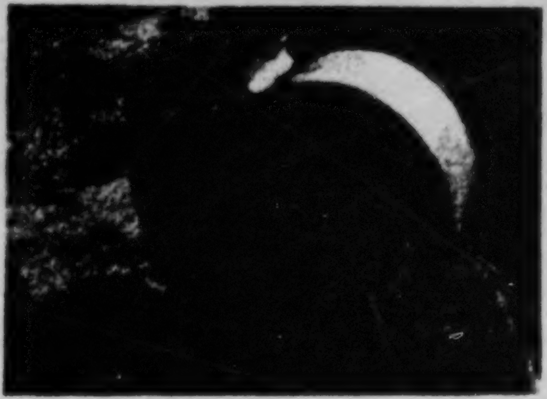

Figure 118 - Squirrel Cage Fan

Locking Devices

Some state laws state that entrances shall be locked, barricaded, or otherwise secured against reentry. This means that to leave any fumigation in such a condition that any person could enter constitutes a violation. Many localities have ordinances requiring special locks. Some require a guard. The types of fumigations where special locks are required, and the times during the fumigation when a guard is required vary. It is the opinion of this writer that a literal interpretation of the (otherwise secured) Act would mean that any fumigation that can be entered by any means is performed in violation, whether special locking devices are used or not.

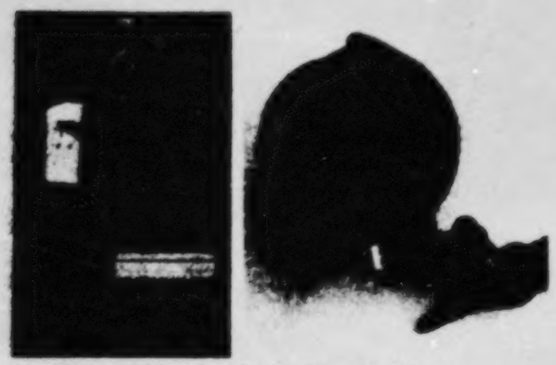

Figure 119 – Pan Lock, Clam Shell Lock

At present there are 3 types of locking devices in use. The most widely used is the "pan lock" (Fig. 119). This is similar to a baking pan with holes in the bottom through which a small chain is passed. The device is placed over the door knob, or handle, and the chain is then wrapped around the knob or handle, passed through the holes and secured with a padlock. The second is a clam shell like device which opens up to slip over the door knob, then closes and locks (Fig. 119). The third is a lock plug that is placed into the keyhole, locked with a special key, thereby closing the keyhole. All of these merely prevent a person from inserting a key into the lock for the purpose of unlocking the door. There is no foolproof method as yet to completely barricade or otherwise secure a building against reentry without the use of a guard.

Releasing Tubing

The safest means of releasing fumigants is to release them from outside the structure by means of tubing attached to cylinder, and leading into the fumigated space. Due to the low boiling point of Vikane, no special vaporizing device is needed, therefore the tubing can lead directly from the cylinder to the area under fumigation. Vikane should be released through 1/4-inch OD polyethylene, polypropylene or nylon tubing (Fig. 120). No tubing larger than this should be used because the rate of flow would be too great for good distribution. Three to five pounds per minute is the best rate of release. The release tube should be positioned so as not to allow the possible frosting of tube to drip onto household effects.

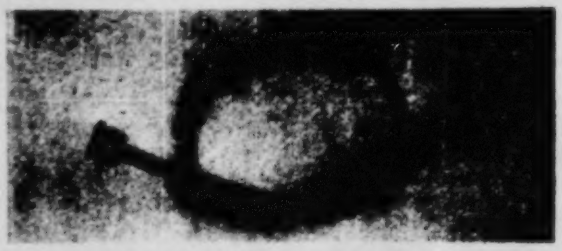

Figure 120 – Releasing Tube

Methyl bromide is usually passed through a heat exchanger in order to vaporize it. The size of the tube leading from the cylinder to heat exchanger should be no larger than 1/4 inch. This prevents too rapid release rate and resultant overloading of heat exchanger. After the fumigant passes through the heat exchanger, it should never be restricted and forced to pass through any opening smaller than the one previously passed through. A good rate of vaporization can be maintained by keeping the tube leading from the heat exchanger to the fumigated space no smaller than 1/2 inch in diameter, 3/4 inch would be better. If restricted, condensation can occur. Methyl bromide should never be released directly onto floors, walls or household effects.

CALCULATING CUBIC CONTENT OF A STRUCTURE

The dosage of fumigants is usually figured on the basis of the number of cubic feet in the space to be fumigated and expressed in thousands of cubic feet. The prices charged for fumigations is also based on this system. Therefore, it is necessary to understand how to calculate the cubic content in any space to be fumigated. In most structures, it can be simply stated that this can be accomplished by multiplying the length by the width, and then multiplying the result by the height. However, one must have some knowledge of how best to do this since most buildings are irregular in shape and have peaked or gabled roofs, and the height used will have to be the average height.

In the following diagram (Fig. 121), which is a simple structure with no additions or wings to consider, the only thing one must understand is the height of this building that will be used is one-half of the height of the attic area added to the height from ground to roof eave. In this case this makes the average height one-half of 6, which is 3, added to the wall height of 10. This gives us the average height. Therefore, the cubic content of this structure would be 40' (length) x 20' (width) x 13' (average height), which gives us 10,400 dubic feet. Now this means that if we are to use a dosage of 3 pounds of fumigant per one thousand cubic feet, we would multiply 10 x 3, since we are using units of thousands for calculating dosage. The answer would be 30 pounds plus an additional 1-1/2 pounds for the extra 400 cubic feet.

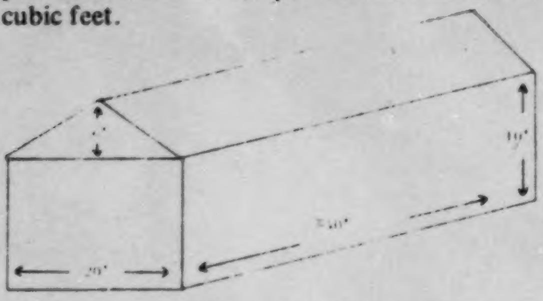

Figure 121 – Diagramatic Sketch of House with no Additional Wings.

The following diagram (Fig. 122) is a little more complicated. Note that a lean-to type room and a sub-area has been added to the main structure. The same procedure as before is followed, but it is easier to understand if calculated in sections. As indicated by the encircled numbers, there are 5 sections. The first one being the number of cubic feet in the main section, less the attic and sub-area. The second one being the main section of lean-to, less the attic and sub-area. The third one being the attic area of main portion of structure. The fourth one being the attic area of lean-to, and the fifth the sub-area of main portion of house plus the sub-area of lean-to.

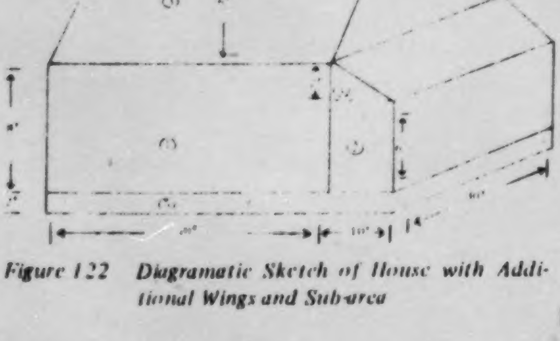

Figure 122 Diagramatic Sketch of House with Additional Wings and Sub-area

To obtain the total cubic content of this structure, cube each of the 5 sections separately, then add them together.

EXAMPLE:

Section No. 1: 40' length x 30' width = 1,200 square feet. 1,200 x height of 8' = 9,600 cubic feet.

Section No. 2: 30' x 10' = 300 square feet. 300 square feet x height of wall – 6' = 1,800 cubic feet.

Section No. 3: 40' x 30' = 1,200 square feet. 1,200 x 1/2 of height of attic which would be 3' = 3,600 cubic feet.

Section No. 4: 30' x 10' = 300 square feet. 300 x 1/2 of the attic height of 1 = 300 cubic feet.

Section No. 5: 40' x 30' = 1,200 square feet + 30' x 10' which is: 300 square feet = 1,500 square feet. 1,500 x sub-area height of 2' = 3,000 cubic feet.

Total number of cubic feet would be:

9,600
1,800
3,600
300
3,000
18,300

At the rate of 2 pounds per thousand cubic feet, the dosage is 2 x 18 units of 1,000 which equals 36 pounds plus approximately 1 pound for the additional 300 cubic feet or, 37 pounds of fumigant.

Sealing the Structure

The quality of the seal is probably the single most important phase of any structural fumigation. Some stucco and masonry buildings can be sealed by covering all exterior openings with laminated paper and masking tape, providing the exterior walls are not too porous, and the roof covering is gastight. Most composition shingle roofs, especially those placed over wood shingles are not gastight. Brick, and most masonry block walls are too porous to effectively confine the fumigant by the paper and tape method. Since all fumigants must have rapid distribution (by means of forced circulation) upon introduction, tape and paper seals are less desirable than covering the entire building with gastight tarpaulins because they lessen the probability of good circulation.

The 3 most important factors in obtaining a good seal on a tarp fumigation are:

1. Condition of the tarps.
2. Tightness of the seal at the ground surface.
3. How tightly the seams are rolled and clamped.

Detailed information on fumigation procedure will be kept essentially basic in this manual, since there are several excellent manuals that cover this subject. A structure that is to be fumigated should be closely inspected to determine:

1. The type of seal.
2. The type of fumigant.
3. The points of application.
4. Location of utility gas shut-off.
5. Items to be removed.

As previously mentioned, buildings with stucco exterior walls in good condition, gastight roof, and without excessive wood trim, can be sealed by the tape and paper type of seal. This is best done by covering all exterior openings (windows, doors, vents) with gastight laminated paper that is secured with 1 inch wide masking tape. It may be necessary to staple the paper in place before taping. The paper should be cut to fit the openings as near as possible, but should extend far enough to cover all wood trim. In other words, the paper should be taped to the stucco on all sides of these openings and not to the trim.

The next step is to seal the vent pipes that extend through the roof. These are usually heater vents. It is not always necessary to seal the plumbing vents, since some of them will have a water seal at the base, and others will not allow gas to enter them anyway. An easy way to seal these vents is to cover them with polyethylene film at least 4 mil in thickness and secure with masking tape or small soft line.

Situations where tarp fumigation is necessary would include buildings with wood siding, shingle or any other type of roof covering that in the fumigator's opinion would not be gastight. Also included are stucco buildings with tile roofs that have wood trim, and buildings with porous masonry block, brick, or stucco walls that are in poor condition. Experience has proven that the most acceptable type of tarp material used is 7 ounce, vinyl-coated nylon. These tarps are made for the fumigation industry, and all fumigators have their own particular sizes that they prefer. About the maximum size that a man can carry up a ladder is 40' by 60'. Every fumigator should have some tarps of smaller dimension in order to work them around obstructions such as antenna, power lines or other structures that might be fastened to the building.

Before placing tarps in position, measurements should be taken to ensure that the best possible use is made of the tarps, thereby eliminating all unnecessary joining together of several small tarps. Since these tarps are joined together (which could be points of leakage), the number of seams should be kept at a minimum. Some antennae can be left in place and worked around, but it is necessary to remove some of them. All sharp corners should be padded by stapling rug pads or other protective material. After fitting the tarps to the building, with at least 2 to 3 feet at the bottom edge resting on the ground for the purpose of sealing, the edges should be joined together by rolling tightly for 3 or 4 turns, and secured with spring clamps spaced no farther apart than 12 to 18 inches. Where stress will occur, they may be placed closer.

There are several methods of sealing the tarps at the ground surface. Probably the best method would be to trench the soil around the building, place the bottom edge in trench, then back fill with soil. This cannot always be accomplished, since some buildings have valuable plantings next to the foundation and the owner will not allow trenching. The next best method would be to haul in damp sand, and after leveling the surface, spread the sand on bottom edge. The most widely used method is by using sand snakes. These are made up of bags that are from 4 to 6 feet in length, approximately 5 inches in diameter, filled with sand and tied at the ends. These are placed on bottom edges of tarps with ends overlapping. The important thing to remember with this method is to have the ground leveled so the snakes will fit snugly to the surface. Some fumigators will double snake. This means at every joint, an extra snake will be placed so as to overlap the joints. Wherever the snakes go over walks, steps, stone outcroppings or uneven ground, extra soil can be placed to level these areas.

The foregoing is a general description of the 2 types of seals, but is not necessarily the sequence of the steps that should be followed to accomplish a fumigation. These 8 steps should ensure a safe fumigation.

A suggested sequence would be:

1. Initial inspection to determine type of seal and how best to accomplish.
2. Inspection of interiors to determine type of fumigant, and what items to remove.
3. Post signs, stating the type of fumigant used, date fumigated, and by whom, in attic and sub-area if any.

4. Danger signs should be posted around the exterior of the building (Fig. 123).
5. Place shooting hoses and sampling tubes for monitoring in structure.
6. Place circulation fans in proper place.
7. Make final check to be sure that no person remains in the building.
8. Lock all doors and secure against reentry.

After completing the job and injecting the fumigant, a check should be made with a leak detection device. All litter should be cleaned up and removed from the premises and proper danger signs posted.

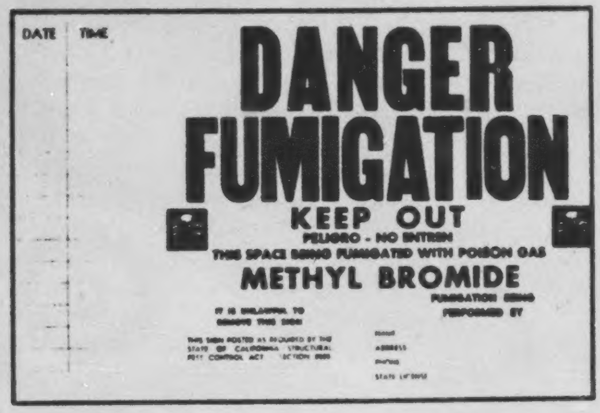
DATE
TIME
DANGER
FUMIGATION
KEEP OUT
PELIGRO - NO ENTREN
THIS SPACE BEING FUMIGATED WITH POISON GAS
METHYL BROMIDE
FUMIGATION BEING PERFORMED BY
IT IS UNLAWFUL TO REMOVE THIS SIGN
ADDRESS
STATE LICENSE

Figure 123 – Sign Should Be Posted Around the Exterior of the Building When Fumigating.

Aeration

A knowledge of the chemical properties of fumigants is essential if one is to thoroughly understand aeration procedure. Fumigants with a high boiling point are more difficult to dissipate from a structure than those with a low boiling point. Terminal concentrations of fumigant remaining at the end of the exposure period will vary according to amount injected, length of exposure, and the degree of confinement. The usual ranges of methyl bromide will vary from 4 to 16 ounces per 1,000 cubic feet, or from 1,000 parts per million to 4,000 parts per million. The amount of Vikane remaining would usually be in the range of from 2 to 8 ounces, or from 500 to 2,000 parts per million. Reoccupancy of the structure should not be allowed until methyl bromide residues have been reduced to at least 20 parts per million, and Vikane residues have been reduced to at least 10 parts per million.

If a check with a Fumiscope is made at the end of the exposure period, it will aid the fumigator to properly plan his aeration. The important thing to remember is to get as many windows and doors open as possible on opposite sides of structure in order to create cross flow of air. This should be done in stages by 2 men wearing approved gas masks, and opening a few windows at a time. Do not attempt to remain in the building long enough to open all windows and doors. The building should then be allowed to stand for awhile before entering to complete the opening of windows. There is usually some work that can be done while this is occurring. No crewmen should be allowed to work or stand in the immediate vicinity of open windows until a considerable amount of aeration has occurred. When a check with a gas detection device shows that the fumigant concentration has been reduced to a level low enough to allow the fumigator to enter without a mask, a thorough check can be made with a gas detector in closed areas, such as, clothes closets, cabinets, furnace wells, and basements to ensure that no transient residues remain. At this time, the utility gas service can be restored and pilots lighted. Usually the fans used in circulating the fumigant during the exposure period will be of help in moving the gas from the larger portions of the building. Since low temperatures slow the diffusion of a fumigant, it will also slow the aeration. Under difficult conditions it may become necessary to employ larger exhaust fans to facilitate the ventilation.

As mentioned before, certain fumigants, due to their chemical and physical properties, are more difficult to clear out of a building than others. Vikane, with its low boiling point and high vapor pressure, possesses properties that are favorable to rapid aeration. Another important factor to consider in aeration is the absorption of the fumigant by certain materials and components in a structure. The usual items in a household do not play a large part in absorption. However, fumigants that are least likely to be absorbed or react with the principal components of a building will penetrate more rapidly, and in the early stages of exposure will be more apt to diffuse into the areas of infestation.

Wood such as fir, which is the most widely used in the framework of residential buildings, has pore space that is so small, they can only be detected with a microscope. Yet all of this pore space will be exposed to a fumigant having no reactive qualities or affinity for wood, and will be desorbed without difficulty. The desorption process of methyl bromide is considerably slower than that of Vikane However, it is considered to be a fumigant with excellent penetrating powers and can be safely aerated from a building with proper aeration procedure. Care should be taken to leave a few windows open, although a detector shows no presence of fumigant. The residues of fumigant that remain in materials not completely desorbed, can build up in the living quarters after the building is completely closed again.

Gas Masks – Canisters and Canister Life

If it becomes necessary to enter a fumigated area, certain types of gas masks fitted with the proper canister for protection against the fumigant being used, should be worn. Be sure that the mask and canister is approved by the U.S. Bureau of Mines. There are limitations as to the amount of gas a canister will absorb, so that after it is used for some time, it becomes saturated or used up and no longer protects the wearer. Three things affect the usable lifetime of a canister. These are; the type of canister, concentration of the gas in the environment and the rate of breathing of the operator. The types of canisters available for use with methyl bromide and Vikane fumigation are presented in Table 15.

Gas Masks

Make sure the mask fits, insert chin well into lower part of facepiece and pull headbands back over head. To obtain a firm and comfortable fit against the face at all points, adjust headbands as follows:

1. See that straps lie flat against head.
2. Tighten lower or neck straps.
3. Tighten the side straps. (Do not touch forehead or front strap).
4. Place both hands on headband pad and push it toward the neck.
5. Repeat operations 1. and 2.
6. Tighten forehead or front strap a few notches.

Table 15. Types of Gas Mask Canister Used With Methyl Bromide and Vikane Fumigation.

METHYL BROMIDE

Type of Canister	Concentration in Pounds per 1,000 Cubic Feet			
	1 lb. or Less	1 to 2 lbs.	2 to 3 lbs.	3 to 4 lbs.
Supersize Black (organic vapors)	120 minutes	60 minutes	45 minutes	30 minutes
Regular Black (organic vapors)	60 minutes	30 minutes	22 minutes	15 minutes
Supersize Yellow (acid gases and organic vapors)	30 minutes	20 minutes	10 minutes	5 minutes
Red All Purpose	18 minutes	13 minutes	10 minutes	5 minutes

VIKANE

Manufacturer	Size	Number	1/4 lb. Per M	1 lb. Per M	2 lbs. Per M
Acme	Large	084-AG	2 hours	15 minutes	No
Acme	Large	084-AGK	2 hours	15 minutes	No
Davis	Large	OC-2 Cat. No. 3237	2 hours	15 minutes	No
M.S.A.	Ind.	GMV 87081	2 hours 1	15 minutes	No
M.S.A.	Large	GMV-SS 87080	2 hours	2 hours	15 minutes

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Bulletin 132-47. Dow Chemical Co. How to Fumigate Buildings with Dow Methyl Bromide.

Fumigation Training Manual. Young. Pest Control Operators of California, Inc.

Training Outline for Safe Practices in Handling and Using Phostoxin Fumigant. Phostoxin Sales, Inc.

Operating Instructions for Fumiscope. Robert K. Hassler Co., P.O. Box 177, Altadena, California.

Toxicological Considerations of Fumigants. Torkelson, Hoyle and Rowe, Biochemical Research Laboratory, Dow Chemical Co., Midland, Michigan.

LEARNING AT HOME

Review Questions – Section 8

1. The color of methyl bromide is: ____________
2. Methyl bromide vapors are ________ times as heavy as air.
3. The dosage of methyl bromide for rats is: ____________
4. Name 3 typical symptoms resulting from repeated exposures to methyl bromide vapors:
   1. ____________
   2. ____________
   3. ____________
5. The presence of Vikane is detected by the use of: ____________
6. ____________ units are used to measure concentration.
7. Excessive single exposures by inhalation of carbon disulfide vapors may produce the following symptoms: ____________
8. When over exposure to hydrogen cyanide occurs, death results from: ____________
9. Ethylene dibromide is ________ toxic than methyl bromide.
10. Aluminum phosphide is formulated in: ____________
11. Name 4 symptoms of a single exposure to Phostoxin fumes:
    1. ____________
    2. ____________
    3. ____________
    4. ____________
12. The inert ingredients in phostoxin are: ____________
13. What size tubing should Vikane be released through: ____________
14. Reoccupancy of a structure should not be permitted until methyl bromide residues have been reduced to: ________
15. Fumigants with a high vapor pressure favor ____________ aeration.
16. What 3 things affect the usable lifetime of a gas mask canister:
    1. ____________
    2. ____________
    3. ____________

OUTSIDE ASSIGNMENTS

1. Conduct some exercises in computing cubic content of structures.
2. Probably the best material for your notebook would be sample labels or at least the pertinent information on the label. This material will enable you to answer customers questions about these highly toxic materials.

ENVIRONMENT

Kenneth R. Hobbs, Ph.D.
Bioecologist
Interdisciplinary Systems, Incorporated

INTRODUCTION

Such words as "environment" and "ecology" are scientific terms that have been used for many years by scientists. Today, they are words that belong in everyone's vocabulary. But as in the case of many developing fields, misconceptions arise even though definitions are given. The understanding of these terms are no exceptions. For example, one hears people saying, "that is good for the ecology." This is just like saying that something is good for Nature. Nature manages itself and the ecological processes exhibit the expected activities of Nature. Before we go any further, then, definitions of these 2 words are important. Durrenberger (1973) defines environment as the sum total of all the conditions and influences that affect the development of an organism. One can say, "that is good for the environment." Each element within these "conditions" and "influences" relates to, and causes changes in all other elements. It is obvious that one change will have a very large effect upon certain specific elements and extremely small effect upon less closely-related elements. A forest fire is a good example, particularly, if the fire is not caused by man. The fire will cause some changes of great magnitude to the immediate environment. The further one travels away from the geographical location of the fire, the less influence the fire element will have.

Everything is in perfect reciprocation or exchange. This does not mean that everything is in "balance." For example, visualize a beam scale with 2 circular platforms upon which you have placed 32 ounces, 16 on each platform. If the scale has the proper adjustment, then the indicator needle should rest on zero. That is perfect balance, at least as perfect as man can make it. However, when you think of the environment (or nature), a balanced scale does not come to mind. One glaring fact presents itself: the environment is in a constant state of change. This means that the organisms are changing the physical environment and the physical environment is changing the organisms. In other words, one might say that organisms are either increasing in numbers or they are decreasing in numbers in given ecological systems (commonly referred to as ecosystem). Again, energy is flowing through the systems and materials are being both produced and used up. Man, himself, is just as intimately tied into this system as any other animal (Smith, 1966).

From this discussion, let us now define the term ecology. Most basically, it is a science which deals with the study of organisms in relation to their environment. It is a study of function and process (Smith, 1966). Fortunately for all creatures, including the plants, environmental biology is very complex. This complexity allows nature to vacillate without throwing it out of gear. This complexity has also allowed man to insert some pressures of various kinds which block these natural and continual changes. These blocks generated by man for his own specific needs, and frequently become so permanent as to injure an environmental process. Remember, the ecology of a system is the interaction at the junction of the 2 natural systems: the biological and the physical.

This leads to one more important definition. The term ecosystem is a word very commonly used today to describe what has just been stated above. More specifically, an ecosystem is a definable, geographical area in which the "conditions" and "influences" are quite predictable. For example, a lake could be considered as an aquatic ecosystem. Temperatures, current, minerals, biological organisms, and other elements can be defined within understandable and expected limits. A desert, small or large, can be considered an ecosystem. Of course, the conditions along the edges of the desert can easily be recognized as different from those occurring near the geographical center of the desert.

ENVIRONMENTAL PROBLEMS WITH PESTICIDES

Dr. Frank S. Lisella, makes some very interesting statements about the double bind man has created for himself with the use of toxicants in the environment.

> On one hand, advancements in the control of disease and innovations resulting in increased agricultural production have called for the widespread use of numerous chemical agents, causing, on the other hand, concern about the effects on the environment from these chemicals and their ultimate impact on the health of man. For example, as early as 1953, it was estimated that at least five million lives had been saved and 100 million illnesses prevented through the use of DDT for controlling malaria, typhus, dysentery and other arthropod (bourne) diseases.
>
> "The impact upon society of advances such as these has come with mixed blessings, and there has been a definite shift in environ-

mental hazards from those with a microbial etiology to those of a chemical nature. The increased productivity of farm land through the systematic application of pesticides may in turn create problems of a public health nature. Among these problems are the potential threats to the exosystem, the hazards created by occupational exposure through the formulation and application of pesticides, and the possible health effects precipitated by chronic exposure to these chemicals.

". . . The home and occupational environments abound with chemicals which are capable of inflicting immediate injury or death. In fact, at any one point in time, there are approximately 250,000 chemical products capable of causing human illness, death, or contamination to wildlife and the environment.

"It has been estimated that approximately 40,000 new potentially poisonous products enter the market each year. In less than 20 years, the use of synthetic chemical pesticides has increased from a level of a few million pounds a year to nearly one billion pounds annually. Today, almost 60,000 different pesticide formulations are registered in the United States, and each contains one or more of the approximately 600 different pesticide compounds. Pesticides have had a tremendous impact on the benefits we have been able to derive from our society. If, for example, we were to look at some of recorded history, we would find the literature replete with writings pertaining to man's continual battle to eliminate or reduce pests.

". . . Obviously, if the nation's food needs are to be met, the productivity per acre must be increased. Pesticides and other agricultural chemicals play a vital role in this connection.

". . . Thus, we are concerned with the widespread dispersal of pesticides and other chemicals, but are placed in a "benefit vs. risk" situation; that is, the advantages to our society must outweigh the detrimental impact the chemicals may have on our environment."

The environmental problems brought about by the use of pesticides are now very well-defined. One could list such problems for pages but there are some obvious generalizations that have become common knowledge. Many of the modern, synthetic pesticides (a collective term for insecticides, miticides, herbicides, rodenticides, etc.) are persistent in the environment; i.e., they leave residues. Long after the need for their toxic qualities have passed, they are still present in lethal or disruptive concentrations. This condition provides the opportunity for these compounds to magnify through various trophic levels (food chains).

This persistence quality manifests a number of other problems with which the operator who handles and dispenses toxic substance should be familiar. So far, the greatest problems occur as a result of attempts to control insects. Uses of toxicants on other categories of pests (weed, rodents, etc.) have been causing certain problems, but not of the same magnitude (Zimdahl, 1972). Man did not realize that nature had already conferred upon insects a genetic mechanism that would allow them to generate races that would not respond repeatedly to applied poisons. For example when DDT was first applied, it annihilated susceptible strains or races of house flies. Flies remaining, naturally developed offspring with less and less susceptible reaction.

Even though there are the so-called broad spectrum and selective compounds, selective materials will not kill just 1 or 2 species of pest. Therefore, no matter what pesticide is used, non-target organisms are harmed or killed. Some of these side effects are caused by the contamination of the air, water supplies, and the soils upon which we place our arsenal of toxicants. Unfortunately, non-target organisms include not only wildlife, domestic animals, and man, but secondary pests and many of the parasitoids and predators of insects. In other words, these poisons wipe out the beneficial wasps, ladybird beetles, green lace wings, and others. The secondary pests that are left then are free to develop into primary pests. Additionally, this principle also causes the primary pests to reappear after treatment in much larger and more damaging numbers than prior to treatment (resurgence).

Another rather interesting problem with pesticides is the fact that they are products sold in the open market. Frequently people who sell those chemicals are compensated by the amount sold. Unfortunately these people also commonly recommend when pests should be treated. Consequently there are times when these sales place unnecessary chemicals in the environment. This process not only results in needless expense to the farmer but may bring about the treadmill of killing beneficial insects and causing more pest problems and hence the use of more and more chemicals.

One of the first and most important changes which can be made to aleviate some of these problems is to investigate the population densities of the most serious pest organisms in relation to crop damage or loss. Out of these type of observations comes the terms "economic level" and pest management. A pest manager is one who knows what the population density is (and in which direction it is going, increasing or decreaing) of each major pest on each crop he is responsible for. As the numbers of a particular pest begins to get dangerously close to the economic level (level at which it may cause damage to a crop), the pest manager developes the most effective, yet least disruptive method for reducing the number of damaging pests. His decisions are based upon considerations of the time of year, environmental conditions, maturity of crops, and many other factors. If a pesticide is deemed advisable in the final decision, it is selected carefully and used properly.

HOW PESTICIDE CONTAMINATION OF THE ENVIRONMENT CAN BE AVOIDED AT THE OPERATOR'S LEVEL

There can be little doubt that the label found on the formulation package is close to the most expensive single page document in common use. In order to develop a new compound with pesticidal qualities for the wholesale and retail trade, a company must spend between 3 and 10 million dollars. The federal laws and many compatible state laws require certain specific information on the label of many substances, particularly pesticides. In order to get the information to put on the label, a lot of experimental and screening work has to be done in every major area where the product will be ultimately sold. This means years of investigation until all of the information needed is ready for the label. The label has all of the information on it that one needs to do a job as safely and as economically as possible. For example, if a company states on one of its labels to use 4 pounds of the formulation for each 100 gallons of water, this is the most effective amount for controlling the pest. In their investigations, it is most likely that they discovered that 2 pounds per 100 gallons controlled less than half of the population tested. Also 8 pounds per 100 gallons most likely did not give any better control than 4 pounds per 100 gallons. Besides not killing any more than the 4 pounds, it remained in the environment too long and caused some detrimental side effects.

The labeling laws also require, among other things, that all the appropriate precautions be clearly stated on the label. These synthetic organic compounds have some very interesting qualities. Many of them are unusual and show little relationship to each other. When the operator prepares to use something toxic that has a label on it, he should read the label carefully. Rarely does the lay person read it thoroughly, let alone a professional. Label information changes because uses, precautions, and concentrations change. Besides not reading what is on the label, there is another common problem. That is that individuals use toxic formulations contrary to the directions on the label. To ignore the label by either means causes environmental contamination. Of course, contamination is not the only problem caused by not following label directions. Too frequently, normal safety precautions are ignored, resulting in injury or death.

Careful selection of the right compound in the right formulation (dust, emulsifiable concentrate, wettable powder, pure, etc.) is as important as reading the label. If one does not have his own experienced knowledge to rely upon, there are many sources of efficient, economical, and up-to-date procedures available to him. Recent literature, agricultural experimentation stations at state universities, consultants (pest managers) and experienced acquaintances, all serve as excellent sources of information as to the best approach. There are state and national associations which have the best of expertise to help the operator with problems relating to the best selection of procedure and toxic material (if one is required) for the most feasible results. The care the operator takes in selection of a toxicant must match the care he exercises in applying a substance which is toxic enough to kill every person he might hit for one second with a spray gun in operation. The less toxic material we have to use, the better. At the moment, however, pesticides must be used in many circumstances where nothing else will solve the problem. Careful application means taking many precautions. It means careful selection of compounds and using properly functioning equipment with accurate gauges. It means well-maintained valves of both rig and guns and keeping good hoses. Precautions also involve making certain that every man or woman who will be handling concentrated toxic substances understands the information on the label and is experienced with the equipment or works with a responsible person who is. The person should be impressed with the importance of following directions in relation to the use of toxic chemicals. If people, new to this field, are not trained with deliberate care concerning these ideas, accidents will continue to happen.

We have mentioned the killing of non-target organisms, including beneficial predators and parasites of pest insects. Closely related to this problem is the accidental killing of honey bees. They are beneficial to man beyond calculation. Ten years of reporting indicates that nearly 47,000 colonies of bees were lost in California in 1962. In 1970, losses had increased to 96,000 and in 1971 the colonies killed figure dropped off to 79,000. The main reasons given for those losses were; 1) because beekeepers put their bees in hazardous locations, and 2) because growers applying pesticides to their crops do not exercise adequate care for protecting honey bees. There are now some sound recommendations for avoiding such losses (Stranger, 1972).

PERSISTENCE, ACCUMULATION AND BIOLOGICAL MAGNIFICATION OF COMMON PESTICIDE GROUPS

Most of the pesticides that are derived from plant parts (botanicals) like pyrethrin, rotenone, ryania, and a number of others decompose within a short time after being applied. Many of these must actually cover the organism they are intended to kill or there will be no effect. Most have low mammalian toxicity and are relatively safe to use, but misuse is still possible. The carrier for these substances is usually deodorized kerosene, which in some cases is as toxic as the added pesticide. Kerosene, as a carrier for many products, can be applied in such a way as to ignite Therefore, care must be exercised in regard to quantity applied in the vicinity of open flames (such as pilot lights).

A comparatively new group of pesticides called organo phosphates (OP) typically breakdown more or less rapidly and are quite susceptible to decomposition by alkaline substances. For example, parathion is listed as breaking down in 3 weeks or less. Insects have not developed resistance to the organo phosphates as rapidly as they have to DDT and its relatives because the OP insecticides are not in the environment long but break down from nearly full strength to almost zero residues (McGovran, 1969). These pesticides range considerably in their toxicity to man. The carbamate insecticides have properties similar to the organophosphate insecticides.

DDT, like one of a large number of chlorinated hydrocarbons, accumulate in the fat tissue of warm blooded animals. Persistance is typical of the compounds that belong to this class. In fact, chlorodane and its relatives have been known to be toxic to termites for over 20 years.

Most of the chlorinated hydrocarbons are volatile to a certain extent, their residual activity is directly related to the amount and period of time they are subject to heat, the presence of oxygen, or sunrays. The presence of all 3 factors in the right combination will greatly enhance the decomposition of substances such as DDT, chlordane, lindane, dieldrin, aldrin, endrin, heptachcholor, and many other toxic compounds (Anonymous, 1970). The length of persistence of a pesticide in the soil, particularly with the chlorinated hydrocarbons depend on many factors. Some of the more important factors include the pesticide itself, soil type, soil moisture, soil temperature, organic matter level, wind or air movement, the crop and its frequency of cultivation, method of application, nature of formulation used, and soil microorganisms. Pesticide residues in the soil may pose several problems to agriculture. Conceivable effects of these residues are injury to crops after application, presence of unacceptable residues absorbed by crops, or harmful effects to living organisms in the soil (Anonymous, 1971). Chlorinated hydrocarbon residues are commonly found in the soil. Most other insecticides such as the organo phosphates (OP) and carbamates (mostly those compounds that actually have the word carbamate in the chemical name) types decompose in soil readily enough so that their residues disappear between crop seasons. However, even certain of the organo phosphates may persist for much longer periods under relatively dry soil conditions.

Most synthetic organic pesticides, (chlorinated hydrocarbon, organophosphrous compounds, carbamates), for all practical purposes, are insoluble in water. For example, parathion is only soluble in water at the rate of about 20 parts per million (ppm). There are some exceptions. For example, phosphamidon is fully soluble in water. In most cases, natural organic or synthetic solvents are used with most modern pesticides. Arsenicals, are also slightly soluble in water. However, this solubility is important. It must be soluble enough to kill the pest, but not soluble enough to injure the plant. This ordinarily means less than 0.5% water solubility.

The persistence of the chlorinated hydrocarbon pesticides allows them to move, by one means or another, from one place to another since they loose their toxicity so slowly. Wherever pesticides are placed in the environment, by whatever means of application, they can and do move. If it is felt that applying persistent toxic substances in a particular situation might eventually cause residue problems elsewhere, other solutions should be examined.

The chlorinated hydrocarbons are both persistent and accumulative in the environment. Suppose that an algae absorbs a pesticide like

DDT into the protoplasm of its cells. Algae frequently are fed upon by other aquatic insects, such as the mayfly. If mayflies are eaten by caddisflies and the caddisflies are consumed by a few dragonflies, the insecticide would be able to increase its concentration at each trophic level (feeding). Once the dragonflies leave the water, adults then could easily be eaten by small insecitivorous birds, which in turn are preyed upon by a small hawk. This process may continue until the very highest feeding organism is reached, which frequently is man. In many cases, the increase of certain toxicants in the biological food chain has had disasterous effects (Coppock, 1972; McGovran, 1969). In the beginning of this section, we emphasized the dependence of one organism upon another. This is nature's mechanism which may result in toxicants to amplify as they go up the food chain. Only one small example of a food chain that might exist in our dynamic environment was given. There are countless numbers of organisms affected by this principle.

HOW PESTICIDES MOVE IN THE ENVIRONMENT

One of the first, and still one of the most common methods, by which pesticides end up where they are not supposed to be is by drift. There are many documented cases which challenge the imagination. For example, a number of years ago, a 2,4-D dust (a hormone herbicide for control of broadleafed weeds and other uses) was applied to a grain crop in the southern San Joaquin Valley. Twenty miles away from the site of the application, a crop of lettuce was severely damaged by the 2,4-D dust.

The continuous search for techniques in reducing drift and other forms of pesticide movement in the environment is being carried on by industry. There are new formulations, new equipment, new timing procedures and new laws regarding safe application (particularly wind). New protective measures are being added continuously during each legislative session of the various levels of government. Additionally, those responsible for monitoring the use of pesticides are always working with the farmer and applicator to help make things as effective as possible without sacrificing safety.

Runoff of chemicals from the soil surface seem to cause minimal problems in the west because waters normally follow natural waterways. However, in the eastern portion of the United States or anywhere that water carries quantities of soil particles, water is also found to carry molecules of nonsoluble chemicals, as found in most pesticides. Less leaching of pesticides from soils takes place than most concerned people think. Water may trickle down through certain soils quite readily. However, unless a toxicant is soluble in water, it is rarely found below 2 inches unless it was mechanically placed deeper. Water must be moving with such a force as to be able to carry soil particles before it can move pesticides. Direct spray placement is one of the best methods to avoid the movement of pesticides in the environment. When an experienced individual is placing compounds under a home to destroy a colony of termites, the pesticide will probably never contaminate the environment until the house is torn down and the soil is returned to some exposed use. Even then there might not be contamination depending on the type of compound used. There are other kinds of direct spray placements that are very important to the agriculturalist. Applying herbicides or insecticides directly upon the organisms that they are intended to kill and using optimum timing would minimize the amount of any pesticide that might move in the environment.

Air and Pesticides

Droplets of spray mixtures settle quite quickly upon various nearby surfaces when pesticides are being applied. It is applied at up to 600 pounds per square inch (psi) at high gallonages. What is being described is the procedure used in applying spray oils to citrus trees. It is applied as an emulsion of a highly refined petroleum oil and water. When these coarse sprays strike leaves and branches, the force is great enough to "break" the emulsion; i.e., the water loosens the oil as it spreads out in a thin film over surfaces and then the water runs off. Different from this type of coarse spray are other extremes, such as the aerosols which never seem to settle. It is some of these "in-between" sprays that have to be applied with great caution. Aerosols are rarely used anywhere except within enclosures where there is no air movement at all, such as in greenhouses, or in and under dwellings. Much conventional spray equipment, particularly weed rigs applying herbicides at 60 psi, emit a spray particle that can be carried to areas where it is not wanted. Where laws are in effect regarding the application of pesticides in relation to wind, 5 miles per hour is the limit. Many formulations are outlawed completely because of their ability to be carried upon air currents for miles. Pesticide equipment companies and weather-measuring instrument companies produce simple, inexpensive wind velocity and direction devices. Even though individuals are normally applying high diluted sprays, one must realize that they are toxic enough to kill the organisms to which they are being applied and thus are dangerous. Think what these compounds can do to more sensitive animals when the materials are being applied if the wind is blowing steadily at about 15 miles per hours. This wind velocity carries airborne toxicants for miles even though the wind is not strong enough to cause an inconvenience to the applicator.

There are a number of things that pest control operators (agricultural or structural) can do to make certain that the maximum amounts being applied remain restricted to the area in which they are applied. Temperature, humidity, wind velocity and direction, size of the spray particle, the volume being applied, and the pressure being used are all conditions that must be considered before a spray rig is started (Anonymous, 1971).

Pollution of Water

Contamination of water by toxic substances can occur by pesticides entering water supplies by direct and intentional application, by inadvertent drift into water from adjacent spraying operations, or by runoff from pesticide-treated areas within a watershed. During recent years there has been a considerable interest focused on the prevalence of pesticides in surface waters. Our rivers and streams provide water for a large number of quality-dependent users, including those served by municipal water supplies, agricultural and industrial consumers and those desiring propagation of fish and wildlife for aesthetic, commercial, and sport purposes, as well as a variety of recreational activities. Runoff from agricultural areas is probably the single most widespread and significant source of low level surface water contamination by pesticides.

Pesticide formulation plants, production plants, firms that reclaim used pesticide containers, operations that apply wool preservatives, textile plants that use pesticides for moth proofing, and similar industrial concerns are often responsible for the discharge of large amounts of pesticides to a water course. Discharges of this type may frequently be responsible for the mortality of various types of aquatic life within the ecosystem. Literature contains numerous references to situations where streams have been grossly contaminated by pesticides either as a result of an accident or by sheer carelessness.

AREAS THAT ARE HIGHLY SENSITIVE

It is very difficult to find a safe, noncontaminating place to discard used pesticide containers or to dump unused spray or dust materials. One immediately might think of a cut-and-fill dump where all such contaminants can be buried with tons of other debris. However, there are a number of categories of pesticides, particularly herbicides, that could be easily carried with percolating waters into the ground waters. This is a sensitive area and special dumps are present and must be used for discarding unused containers and materials.

Whenever toxic compounds are being applied, all sensitive areas should be considered. Schools, playgrounds and other recreational areas should be avoided, particularly when they are occupied. If controls are being applied to nearby ornamental trees and shrubs, children in the area are certain, out of curiousity, to move in close enough to be able to observe what is going on. On one occasion, a number of years ago, an experienced pest control operator was observed spraying walnut trees in a tract area. One half of one percent of parathion, among other toxicants, was being applied. Sprayed trees were dripping copiously. Neighborhood children and their pets were everywhere. The operator was paying little attention to them. When asked what he was spraying, he stated that he didn't know. Conditions just like this, are responsible for the loss of many wildlife habitats, domestic pets, and lives of humans.

HOW TO PLAN APPLICATION TO AVOID PESTICIDE DAMAGE

The first and foremost technique for confining the storage and use of pesticides to specific areas where they are wanted, is to be continuously aware of exactly what you are doing. Reading the label and following directions exactly as they are presented is another highly successful precaution. Selecting the right toxicant which has been prepared in the most appropriate formulation, applying it at precisely the right time of year and the right time of the day, using equipment in proper working order and using experienced people who have needed concern for environmental contamination is the surest way of avoiding problems. Keeping alert for leaking sacks or cans used for transporting pesticide concentrates could save many lives. Discarding all used containers which contained toxic chemicals (there is no such thing as an "empty" pesticide container) so there is no possibility that unauthorized people can handle them or become contaminated, is a most important precaution. Today, labels also explain how many days after application it is safe for agricultural workers to re-enter treated fields. Read the label and follow all of the directions. Unauthorized use is a frequent cause of much of the pesticide damage that is reported today.

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LEARNING AT HOME

Review Questions – Section 9

1. Which of the 2 groups of pesticides breaks down more rapidly and presents the least environmental hazard:
   a. Organophosphates.
   b. Chlorinated hydrocarbons.
2. What is meant by "non-target organism": ____
   ____
3. The most common cause of drift is ____
4. The loss of honey bee colonies due to pesticides can be minimized if pesticides are applied that: ____________________
5. Name 3 ways in which pesticides can move in the environment:
   a ____
   b ____
   c ____
6. List 3 detrimental effects of allowing pesticides to kill non-target organisms:
   1. ____
   2. ____
   3. ____
7. "Persistence" is associated with which group of pesticides: ____________________
8. List 3 problems that might be posed by residues of persistent pesticides in soil:
   1. ____
   2. ____
   3. ____
9. ____ may be adversely affected or might actually help to break down certain persistent pesticides in soil:
10. What would be the reason for more movement in the environment of persistent pesticides: ________________
    ____
11. The most common cause of the movement of pesticides in the environment is:
    ____
12. List 5 conditions that an applicator should consider before starting up his spray rig:
    1. ____
    2. ____
    3. ____
    4. ____
    5. ____
13. ____ is probably the most significant source of low level surface water contamination.
14. List 5 things an applicator can do when preparing to apply pesticides that will help to avoid problems:
    1. ____
    2. ____
    3. ____
    4. ____
    5. ____

OUTSIDE ASSIGNMENTS

Make a list of the "do's" and "dont's" of pesticide application. These should be comprised of steps to take and things to avoid that will assure the applicator that he will not apply pesticides in such a manner that will harm the envrionment. Take into consideration such things as sensitive areas, run off, drift, protection of wildlife and water supplies.

LAWS AND REGULATIONS

There are several federal agencies which promulgate regulations affecting the pesticide applicator. Each of the agencies and their functions are discussed in the following section.

FOOD AND DRUG ADMINISTRATION

The Food and Drug Administration (F.D.A.) enforces the Federal Food, Drug, and Cosmetic Act, Caustic Poisons Act, Hazardous Substances Labeling Act, Tea Importation Act, and Filled Milk Act. Its activities are directed mainly toward promoting purity standard potency, truthful and informative labeling of consumer products covered by these laws. The F.D.A. operates under the direction of the Commissioner of Food and Drugs, who is responsible to the Secretary of Health, Education and Welfare.

Safe amounts of pesticides in foods have been regulated through sections 408 and 409 of the Federal Food, Drug, and Cosmetic Act. It has been recognized for some time that contamination of foods might result from use of insecticides in food handling establishments such as canneries, restaurants, and warehouses. To assist in the regulatory control of insecticides in food handling establishments, the following definitions will be used:

1. Food is defined by section 201(f) of the Federal Food, Drug and Cosmetic Act to mean (1) articles used for food or drink for man or other animals, (2) chewing gum, and (3) articles used for components of any such article.
2. A food handling establishment is an area or place other than a private residence in which food is held, processed, prepared and/or served.
   a. Nonfood areas of food handling establishments include garbage rooms, lavatories, floor drains (to sewers) entries and vestibules, offices, locker rooms, machine rooms, boiler rooms, garages, mop closets, and storage (after canning or bottling).
   b. Food areas of food handling establishments include areas for receiving, serving, storage (dry, cold, frozen, raw), packaging (canning, bottlings, wrapping, boxing), preparing (cleaning, slicing, cooking, grinding), edible waste storage, enclosed processing systems (mills, dairies, edible oils, syrups).
3. Nonresidual insecticides are those products applied to obtain insecticidal effects only during the time of treatment and are applied either as space treatments or contact treatments.
   a. Space treatment is the dispersal of insecticides into the air by foggers, misters, aerosol devices or vapor dispensers for control of flying insects and exposed crawling insects.
   b. Contact treatment is the application of a wet spray for immediate insecticidal effect.
4. Residual insecticides are those products applied to obtain insecticidal effects lasting several hours or longer and are applied as general, spot, or crack and crevice treatments.
   a. General treatment is application to broad expanses of surfaces such as walls, floors, and ceilings or as an outside treatment.

UNITED STATES DEPARTMENT OF AGRICULTURE

The United States Department of Agriculture (U.S.D.A.) is administered by the Secretary of Agriculture and is directed by law to acquire and diffuse information on a broad range of agricultural subjects. The Department performs functions relating to research, education, conservation, marketing, regulatory work, agricultural adjustment, surplus disposal and rural development. It conducts research in agricultural chemistry, the industrial uses of farm products, entomology, soils, agricultural engineering, agricultural economics, marketing, crop and livestock production, production and manufacture of dairy products, human nutrition, home economics, forestry and conservation. It makes research results available for practical farm application through experiment station work in cooperation with the States. The Department provides crop reports, commodity standards, federal meat and poultry inspection service, and other inspection, grading and marketing services. It works toward the eradication and control of plant and animal diseases and pests. In connection with these and other functions the Department administers many regulatory laws and may play a major part in the certification of pesticide applicators.

O.S.H.A.

The Williams-Steiger Occupational Safety and Health Act of 1970 provides for job safety and health protection for all workers. The key provisions of the Act requires that each employer must furnish to each of his employees a place of employment which is free from recognized hazards that are likely to cause death or serious physical harm. O.S.H.A. sets certain standards dealing with toxic materials. It provides for protective equipment to guard against undesirable exposures to liquids, dusts, mists, vapors or gases. It provides for proper storage of pesticides, decontamination, clean up of pesticide spills and safe transportation of pesticides on service vehicles.

DEPARTMENT OF TRANSPORTATION

The Department of Transportation (D.O.T.) regulates the shipment of pesticides across state lines. Each hazardous material being transported must meet D.O.T. standards. These standards regulate warning signs, packaging and classes of poisons that may or may not be transported in the same vehicle. Whenever there is a spill of hazardous materials during shipment, it must be reported to D.O.T.

ENVIRONMENTAL PROTECTION AGENCY

The most significant to the pesticide applicator of all the government agencies is the Environmental Protection Agency (E.P.A.). In 1972 Congress passed a law called the Federal Environmental Pesticide Control Act (FEPCA).

The new Act completely revised the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) which has been the basic authority for Federal pesticide regulation since 1947.

The law prior to the new legislation prohibited interstate commerce of unregistered pesticides, and permitted registration only when if used as directed or in accordance with commonly recognized practice the pesticide would not be injurious to man, vertebrate animals, or desirable vegetation. It did not prohibit the misuse of any registered pesticide, nor did it regulate pesticides that moved only in intrastate commerce.

The new Act regulates the use of pesticides to protect man and the environment and extends Federal pesticide regulation to all pesticides including those distributed or used within a single State.

Major provisions of the new Act will:

prohibit the use of any pesticide inconsistent with its labeling. No pesticide may be registered or sold unless its labeling is such as to prevent any injury to man or any unreasonable adverse effects on environmental values, taking into account the public interest, including benefits from its use.

– require pesticides to be classified for general use or restricted use. Restricted use pesticides may be used only by or under the supervision of certified applicators or subject to such other restrictions as the Administrator of EPA may determine.

– strengthen enforcement by: requiring the registration of all pesticide producing establishments, and regular submission by them of production and sales-volume information; authorizing entry of establishments and other places where pesticides are held for sale or distribution for inspection and obtaining samples; authorizing stop sale, use, or removal orders and seizure against hazardous pesticides if necessary; providing civil and increased criminal penalties; authorizing cooperation with States; and improving procedures governing registration and cancellation actions by allowing scientific review and public hearings to be held concurrently.

– give applicants for registration propriety rights in their test data but establishes a mandatory licensing system whereby such data could be used by a second applicant upon the payment of reasonable compensation.

authorize the payment of ideminities to persons holding pesticides before the issuance of a suspension notice if the pesticide is finally cancelled; except a manufacturer may not receive any ideminity if he had knowledge of facts that the pesticide should be suspended or cancelled and does not advise the Administrator.

– authorize the Administrator to establish pesticide packaging standards, regulate pesticide and container disposal; issue experimental use permits, conduct research on pesticides and alternatives and monitor pesticide use and presence in the environment.

– provide for certification of pesticide applicators by the States under a program approved by the Administrator; for cooperative enforcement with States; grants-in-aid and other assistance to States. States are also authorized to issue conditional registrations for pesticides intended for specific local use, and could impose greater regulation on a pesticide than that of the Federal government, except as to packaging and labeling.

establish a series of effective dates for various provisions of the Act and continues the existing law in effect until the new provisions become effective. Every provision of the new Act must be effective within four years.

SECTION BY SECTION SYNOPSIS OF THE MAJOR PROVISIONS OF THE CONFERENCE PESTICIDE BILL

Section 1 of the bill states its purpose and title.

Section 2 of the bill sets forth the amendments to the Federal Insecticide, Fungicide, and Rodenticide Act, as amended:

Amendments to FIFRA

Section 1. Short Title and Table of Contents

Section 2. Definitions

Section 3. Registration of Pesticides

1. With certain exceptions, any pesticide in U.S. trade must be registered with the Administrator.
2. In order to obtain registration, a pesticide producer must submit an application identifying himself and the pesticide, showing the labeling, and stating claims to be made, directions for use, the pesticide formula, requested classification, and test data and results which support the claims made.

   The Administrator may not consider the test data supporting one application in support of another application without the originator's permission or unless the second applicant has first offered to pay reasonable compensation for the test data. If the parties cannot agree on the amount and method of payment, the Administrator makes the determination. If the owner of the test data does not agree with the determination, he may appeal to a Federal district court. The court may not determine that the amount of payment should be less than that determined by the Administrator.
3. All information except trade secrets and privileged information in support of registration must be made available to the public within 30 days of the registration.
4. A pesticide which meets the requirements of the Act shall be registered, and non-essentiality cannot be a criterion for denial of registration.
5. If registration is denied, notice of the denial and reasons for denial must be published in the Federal Register. The applicant then has recourse to administrative and judicial appeals.
6. Registered pesticides will be classified for either general use or restricted use. A pesticide would be restricted because of its potential for harm to either human health or the environment.

   The Administrator may require that the packaging and labeling of a pesticide for its restricted uses be clearly distinguishable from its general uses.

   A restricted use pesticide which is a hazard to human health is subject to the restriction that it be applied by a certified pesticide applicator, who is certified by the State according to standards set by the Administrator and may be either a commercial or private certified applicator.

   A pesticide classified for restricted use because it could harm both health and the environment can be made subject to other restrictions by regulation, which are reviewable in a court of appeals.

   The Administrator may change a pesticide classification but the action is subject to administrative and judicial review.

Section 4. Use of Restricted Use Pesticides; Certified Applicators

1. The Administrator sets minimum standards for the certification of applicators, which are to be separate for private and commercial applicators.
2. Certification will be accomplished by State programs whose plans are approved by the Administrator. The Administrator may withdraw approval of a State plan if the program is not maintained in accordance with it.

Section 5. Experimental Use Permits

1. The Administrator may issue permits and set the terms for the experimental use of a pesticide in order to gather data for registration, and may establish a temporary pesticide residue tolerance level for that purpose.
2. The Administrator may authorize a State to issue experimental use permits under an approved plan.

Section 6. Administrative Review; Suspension

1. Registrations are automatically cancelled after 5 years unless a request is made that they be continued.
2. If the Administrator has reason to believe a registered pesticide does not comply with the Act or that it, when "used in accordance with widespread and commonly recognized practice, generally causes un-

reasonable adverse effects on the environment", he may move to cancel the registration or change the classification of the pesticide. The registrant is notified and may correct the deficiency or request a public hearing. The Administrator may also decide to hold a hearing on a registration to determine whether or not cancellation or change in classification should ensue.

3. At any time during a hearing a question of relevant scientific fact may be referred by the Hearing Examiner to a Committee of the National Academy of Sciences for a report. The Hearing Examiner may also compel testimony or production of documents by subpoena. Within 90 days from the close of a hearing the Administrator must issue an order regarding the registration in question.
4. If the Administrator finds such action necessary to prevent an imminent hazard to health or the environment during the pendency of cancellation or change in classification proceedings, he may suspend the registration after 5 days notice to the registrant, who may within that period request an expedited hearing on the imminent hazard finding. The suspension order would not take effect until any requested hearing had been completed.

   The Administrator may issue an emergency suspension order, taking effect immediately, when necessary; and any subsequent hearing would be expedited.
5. Final orders of the Administrator under this section are subject to judicial review under section 16. However, orders issued prior to hearing would be reviewed in an appropriate district court.

Section 7. Registration of Establishments

1. Pesticide producing establishments are required to be registered with the Administrator.
2. Producers are required to submit upon initial registration and annually information on the amount of pesticides produced, distributed, and sold.

Section 8. Books and Records

1. The Administrator may require pesticide and device producers to maintain records respecting their operations which are necessary for enforcement of the Act.
2. Records on the location and movement of pesticides or devices are to be accessible to the Administrator's agent upon request for inspection and copying.
3. Financial, sales, pricing, personnel, and research data are excluded from the above requirements.

Section 9. Inspection of Establishments

1. The Administrator's agent may enter any establishment or other place where pesticides or devices are held for distribution and sale, inspect pesticides or devices, and take samples. The agent must state a sufficient reason for his action.
2. A warrant to enter a place and inspect and reproduce records may be obtained when the Administrator's agent shows there is reason to believe the Act has been violated.
3. If a violation of the Act appears to have occurred, the Administrator shall notify the suspected violator, and shall certify the facts to the Attorney General for the institution of criminal or civil proceedings. However, for minor violations the Administrator may issue a warning instead.

Section 10. Protection of Trade Secrecy and Other Information

1. In submitting required data, a registration applicant may mark the portion he considers trade secrets, or commercial or financial information, and submit it separately.
2. The Administrator may not make information public if it comprises trade secrets, or commercial or financial information. However, pesticide formulas may be revealed in certain instances in order to carry out the purposes of the Act.
3. Disputes between the Administrator and an applicant or registrant concerning releasable information would be resolved in a district court by declaratory judgment.

Section 11. Standards Applicable to Pesticide Applicators

1. No regulations under the Act may require a private applicator to maintain records or file reports.
2. Private and commercial applicator certification standards set by the Administrator must be separate.

Section 12. Unlawful Acts

A number of unlawful acts are contained in he section which relate to the requirements of he other sections of the bill pertaining to registration of pesticides and producing establishments, record-keeping and reporting, pesticide use, and others. Additional unlawful acts include not giving a pesticide's classification when advertising and failure to fully inform persons involved in pesticide testing.

Section 13. Stop Sale, Use, Removal, and Seizure

1. When it appears a pesticide is in violation of the Act or its registration has been suspended or cancelled by final order, the Administrator may issue a "stop sale, use, or removal" order to any person.
2. Pesticides in violation of the Act may be seized, as may misbranded devices and pesticides which have an unreasonable adverse effect on the environment even when used in accordance with requirements and as directed on the labeling.

Section 14. Penalties

1. Any registrant, commercial applicator, wholesaler, dealer, retailer, or other distributor is liable to a $5,000 civil penalty for an Act violation. Private applicators and other persons are liable only to a $1,000 civil penalty on their second and subsequent offenses. Opportunity for hearing is required prior to assessment of a civil penalty.
2. Any registrant, commercial applicator, wholesaler, dealer, retailer, or other distributor is liable to a penalty of $25,000 or 1 year in prison or both upon conviction for a misdemeanor. Private applicators and other persons are liable to $1,000 or 30 days in prison or both. Persons who reveal formula information are liable to $10,000 or 3 years in prison or both.

Section 15. Indemnities

1. Persons owning a pesticide whose registration is suspended and later cancelled are eligible for payment by the Administrator of an indemnity for the pesticide owned. Manufacturers who had knowledge prior to the issuance of a suspension notice that their products did not meet registration requirements and who continued to produce the pesticide without notifying the Administrator of the deficiency would not be eligible.
2. In lieu of indemnification the Administrator may authorize under certain limited conditions the use or other disposal of a pesticide.

Section 16. Administrative Procedure: Judicial Review

1. Except as otherwise provided, EPA refusals to cancel or suspend registration or change classifications which do not follow a public hearing are reviewable in district courts, as are other final non-discretionary Agency actions.
2. Review of an order of the Administrator will occur in a court of appeals upon the request of any person who will be adversely affected by the order and who took part in the public hearing leading to the order. The court shall review all evidence of record, and commencement of proceedings does not operate as a stay of an order unless specifically ordered by the court.
3. District courts have jurisdiction to specifically enforce and to prevent and restrain violations of the Act.

Section 17. Imports and Exports

1. Producers of exported pesticides or devices are subject to the requirements of Section 8, Books and Records, but are otherwise required only to prepare the product as specified by the foreign purchases in order to comply with the Act.
2. The Administrator is required to notify foreign governments through the State Department whenever the registration, or the cancellation or suspension of the registration of a pesticide becomes effective or ceases to be effective.
3. The Administrator is authorized to examine imported pesticides or devices and have those in violation of the Act refused entry, seized, and destroyed.

Section 18. Exemption of Federal Agencies

The Administrator may exempt any Federal or State agency from the Act if he determines that emergency conditions exist which require such exemption.

Section 19. Disposal and Transportation

The Administrator shall establish procedures and regulations for storage or disposal of pesticides and containers. He is required to accept at convenient locations for disposal a pesticide whose registration is suspended, then cancelled.

Section 20. Research and Monitoring

Authority for pesticide research and monitoring is provided, including research contracts and grants. Cooperation with other governmental agencies is authorized for research and monitoring purposes. A National Monitoring Plan is required to be formulated and carried out by the Administrator.

Section 21. Solicitation of Comments: Notice of Public Hearings

1. The Administrator is required to solicit the

views of the Secretary of Agriculture before publishing regulations under the Act.
2. The Administrator is authorized to solicit the views of all interested persons concerning any action under the Act and seek advice from qualified persons.
3. Timely notice of any public hearing to be held shall be published in the Federal Register.

Section 22. Delegation and Cooperation

1. The Administrator may delegate his authority under the Act.
2. The Administrator shall cooperate with appropriate governmental agencies in order to carry out the Act.

Section 23. State Cooperation, Aid, and Training

1. The Administrator may delegate to a State the authority to cooperate in enforcement of the Act, train State personnel in cooperative enforcement, and assist States to implement co-operative enforcement with grants.
2. The Administrator may assist States in developing and administering applicator certification programs under cooperative agreements and under contracts.
3. The Administrator may utilize the Cooperative State Extension Services to inform farmers of measures taken under the Act.

Section 24. Authority of States

1. A State may impose greater regulation on the sale or use of a pesticide than that of the Federal Government. However, different State packaging or labeling requirements are prohibited.
2. States certified by the Administrator may register pesticides formulated for distribution and use within its bounds, and the registration is permanent if not disapproved by the Administrator within 90 days.

Section 25. Authority of the Administrator

1. The Administrator may exempt from the Act pesticides which do not require regulation, or are adequately regulated under other Federal law.
2. The Administrator is authorized to declare that which is a pest; determine highly toxic substances in pesticides; specify classes of devices subject to certain misbranding provisions and Section 7; prescribed pesticide discoloration requirements; and determine suitable pesticide names.

Section 26. Severability

The Act is severable in that the invalidity of one provision would not invalidate the remaining provisions.

Section 27. Authorization for Appropriations

Such sums as are necessary are authorized to be appropriated through June 30, 1975, and thereafter as provided by new legislation.

Remaining Bill Provisions

Section 3 of the bill contains technical amendments making other Acts conform to amended FIFRA.

Section 4 of the bill provides the effective dates of provisions of the FIFRA amendments.

1. Two years after enactment the Administrator shall have promulgated registration and classification regulations and thereafter shall register new applications under those regulations.
2. After two years but within 4 years existing registrations shall be registered and reclassified in accordance with the regulations described in 1 above.
3. Any requirement that a pesticide be registered for use only by a certified applicator shall not be effective until 4 years from enactment.
4. A period of 4 years from enactment shall be provided for certification of applicators, with certification standards prescribed within one year and State certification plans submitted to the Administrator within 3 years and approved by the Administrator within one year of submission.
5. One year after enactment regulations governing registration of establishments, experimental use permits, and keeping of books and records shall be made effective.
6. No person shall be subject to any penalty before 60 days after the publication of pertinent regulations in the Federal Register and after the Administrator has taken such other action as may be necessary to permit compliance with the pertinent provision.
7. Except as otherwise provided above, all amendments take effect upon enactment or, if regulations are required, within 90 days, when such regulations are to be effective.
8. Provisions of FIFRA prior to enactment of the bill remain in effect until superseded by the amendments in the bill, but all amendments are to be effective within 4 years of enactment.

KEY POINTS THAT AFFECT THE APPLICATOR

1. In general, the Act will divide pesticides into 2 classifications. These will be termed **General Use** and **Restricted Use**. At the time pesticides are registered, EPA will decide whether the use will be classified as general or restricted. EPA makes it clear that the classification will be by pesticide use, not by the chemical pesticide per se.

   If a pesticide, when used in accordance to directions, will not harm the environment to an unreasonable degree, it can be classified as general use. But if it could harm the environment or the applicator, even when used as directed, it will be classified as restricted use.
2. The Act also sets the standards for what must appear on the label, directions for use, container disposal, first aid instructions and environmental warnings (refer to section on labeling).
3. It prohibits the applicator whether certified or not from using a pesticide in any manner other than that directed on the label. This means that if a pesticide is not registered to control a certain pest, it cannot be used for the control of that pest. It also means that the manner of application specified on the label must be adhered to. Example: if the label does not specify use in a fogging device, this means the pesticide is not to be fogged. The Act also provides that the label specify the rate of application. If the label states that it is to be used at the rate of a specified number of gallons to a given area, then to use the pesticide at a higher or lower rate other than that on the label would be a violation.
4. If an operator violates the Act, he may be subject to either civil or criminal penalties. He may be subject to a civil penalty of as much as $5,000 for each offense if he violates the Act unintentionally. If he knowingly or deliberately violates the Act, he may be fined up to $25,000 or sentenced to prison for one year or both.
5. Although F.D.A. regulates the safe amounts of pesticides (residues) that may remain on foods, E.P.A. sets these tolerances when the pesticide use is registered.
6. Probably the most important provision of the Act calls for the certification of all applicators who apply restricted use pesticides.

Environmental and human health problems associated with the use and misuse of pesticides can be divided into several categories among which are acute impact on human health, localized environmental effects and potential long-term health effects, i.e., environmental effects extending beyond the immediate pesticide application site. Acute health effects and localized environmental effects are largely associated with the improper handling and use of pesticides by the individual applicator. Certification can be a basis for ensuring that pesticide users have sufficient practical knowledge to protect themselves and others from acute health effects and to prevent the most common types of localized environmental damage. The proposed standards require such knowledge for certification.

The other problems are associated with the extent of use by all applicators and the characteristics of pesticides, for example, mobility, persistence, and tendency to bioaccumulate in the food chain. There is obviously some overlap. For example, pesticide runoff into streams can create a localized water contamination problem and also contribute to wide-spread environmental contamination.

The exact impact of applicator certification on the problems of potential long-term health effects and widespread environmental effects is unknown. However, it is apparent that certification can have some impact. For example, application techniques and precautions which minimize acute health hazards reduce some of the hazards associated with repeated applications and chronic exposure. Since the certification standards stress a practical knowledge of pesticide usage, a certified applicator should be cognizant of application techniques which can mitigate these environmental effects. The additive effect of good practices by more responsible applicators can be expected to lessen the possibility of protracted undesirable effects.

However, it is clear that the certification, alone is not adequate to prevent long-term human health and widespread environmental problems. Applicators generally have less reason to consider the widespread environmental effects of a particular application than to protect themselves and others from being poisoned. Even more important, an individual applicator normally is never in a position to control total usage of a given pesticide in a specific area during a growing season. To meet these problems Congress provided other regulatory mechanisms in the FIFRA as amended.

The categories discussed in the following sections have been established by E.P.A. for commercial applicators of pesticides. The states shall adopt these categories as needed, along with such other categories or sub-categories as needed. Some of the states have grouped the applicators of pesticides for the control of structural pests into one category. Others have established several groups for licensing purposes and may find it necessary to establish subcategories to meet their particular requirements.

It is EPA's position that sophisticated academic training should not be necessary to equip an applicator to do such things as identify common types of pests, comprehend instructions and warnings on a pesticide label, make the calculations necessary to arrive at a proper dilution of the product, calibrate application equipment, identify and avoid situations that obviously will result in injury to non-target species, make proper use of protective clothing, and keep pesticide containers out of children's reach.

In developing the proposed standards, EPA considered the following alternatives in defining the nature and scope of problems applicator certification should meet:

1. Applicator certification should be designed to ensure competence with respect to prevention not only of acute health effects and localized environmental damage, but also long-term health hazards and widespread environmental problems.
2. Applicator certification should be mainly designed to ensure competence with respect to prevention of acute human health effects and localized environmental problems.

EPA also considered the following alternatives in defining the level of knowledge that an applicator should be expected to have:

1. **Academic level.** Full comprehension of the principles and practices of pest control, plus practical knowledge of pesticide application techniques and problems.
2. **Operational level**. Practical knowledge of pest problems, environmental and health concerns, and application techniques and precautions.

Based on the considerations outlined above, the latter alternative was adopted in each case. The proposed standards are written in such a way as to require certified applicators to have practical knowledge relevant to prevention of acute health effects and localized environmental contamination. This approach is the one most directly related to the ways in which applicator certification can mitigate the problems arising from improper use of pesticides. At the same time, it ensures that pesticide application will be increasingly in the hands of well trained, more responsible people. The former alternative would require a more comprehensive and sophisticated certification program without necessarily having any greater impact on the environmental hazards.

E.P.A. certification of applicators who apply toxic pesticides fall into the following categories:

Agricultural Pest Control

Plant

This category includes commercial applicators using or supervising the use of restricted use pesticides in production of agricultural crops, including without limiting the foregoing, tobacco, peanuts, cotton, feed grains, soybeans forage, vegetables, small fruits and nuts, as well as on grasslands and non-crop agricultural lands.

Animal

This category includes commercial applicators using or supervising the use of restricted use pesticides on animals, including without limiting the foregoing, beef cattle, dairy cattle, swine, sheep, horses, goats, poultry, and livestock, and to places on or in which animals are confined. Doctors of veterinary medicine engaged in the business of applying pesticides for hire, publicly holding themselves out as pesticide applicators, or engaged in large-scale use of pesticides are included in this category.

Forest Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides in forests, forest nurseries, and forest seed producing areas.

Ornamental and Turf Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides to control pests in the maintenance and production of ornamental trees, shrubs, flowers, and turf.

Seed Treatment

This category includes commercial applicators using or supervising the use of restricted use pesticides on seeds.

Aquatic Pest Control

This category includes commercial applicators using or supervising the use of any restricted use pesticide purposefully applied to standing or running water, excluding applicators engaged in public health related activities including the category of public health pest control.

Right-of-Way Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides in the maintenance of public roads, electric powerlines, pipelines, railway rights-of-way or other similar areas.

Industrial, Institutional, Structural and Health Related Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides in, on, or around food handling establishments, human dwellings, institutions such as schools and hospitals, industrial establishments, including warehouses and grain elevators, and any other structures and adjacent areas, public or private; and for the protection of stored, processed, or manufactured products.

Public Health Pest Control

This category includes State, Federal or other governmental employees using or supervising the use of restricted use pesticides in public health programs for the management and control of pests having medical and public health importance.

Regulatory Pest Control

This category includes State, Federal or other governmental employees who use or supervise the use of restricted use pesticides in the control of regulated pests.

Demonstration and Research Pest Control

This category includes individuals who demonstrate to the public the proper use and techniques of application of restricted use pesticides or supervise such demonstration, and persons conducting field research with pesticides, and in doing so, use or supervise the use of restricted use pesticides. Included in the first group are such persons as extension specialists and county agents, commercial representatives demonstrating pesticide products, and those individuals demonstrating methods used in public programs. The second group includes state, federal, commercial and other persons conducting field research on or utilizing restricted use pesticides.

Other Categories and Subcategories

Any state submitting a plan pursuant to this section for the certification of applicators, as provided for below, may designate such subcategories within the above 10 categories as it deems necessary. In addition, a state may delete a category not needed or may request the Administrator's approval of additional major categories.

DETERMINATION OF COMPETENCY

Competence in the use and handling of pesticides shall be determined on the basis of written examinations, and, as appropriate, performance testing, based upon standards set forth below and which are approved by the Administrator. Such examination and testing shall include the general standards applicable to all categories and the additional standards specifically identified for each category or subcategory (if any) in which an applicator is to be classified. State standards must conform and be at least equal to those prescribed herein. In developing the details of standards at the state level and in structuring examinations, it is important to recognize and reflect the extent of competency appropriate and necessary to a particular category.

General Standards for All Categories of Certified Commercial Applicators

All commercial applicators shall demonstrate practical knowledge of the principles and practices of pest control and safe use of pesticides. Testing shall be based on examples of problems and situations appropriate to the particular category or subcategory of the applicator's certification and the following areas of competency:

Label & Labeling Comprehension

1. The general format and terminology of pesticide labels and labeling.
2. The understanding of instructions, warnings, terms, symbols and other information commonly appearing on pesticide labels.
3. Classification of the product, general or restricted; and
4. Necessity for use consistent with the label.

Safety

Factors including:

1. Pesticide toxicity and hazard to man and common exposure routes.
2. Common types and causes of pesticide accidents.
3. Precautions necessary to guard against injury to applicators and other individuals in or near treated areas.
4. Need for and use of protective clothing and equipment.
5. Symptoms of pesticide poisoning.
6. First aid and other procedures to be followed in case of a pesticide accident.

7. Proper identification, storage, transport, handling, mixing procedures and disposal methods for pesticides and used pesticide containers, including precautions to be taken to prevent children from having access to pesticides and pesticide containers.

Environment

The potential environmental consequences of the use and misuse of pesticides as may be influenced by such factors as:

1. Weather and other climatic conditions.
2. Type of terrain, soil or other substrate.
3. Presence of fish, wildlife and other nontarget organisms.
4. Drainage patterns.

Pests

Factors such as:

1. Common features of pest organisms and characteristics of damage needed for pest recognition.
2. Recognition of relevant pests.
3. Pest development and biology as it may be relevant to problem identification and control.

Pesticides

Factors such as:

1. Types of pesticides.
2. Types of formulations.
3. Compatibility, synergism, persistence and animal and plant toxicity of the formulations.
4. Hazards and residues associated with use.
5. Factors which influence effectiveness or lead to such problems as resistence to pesticides.
6. Dilution procedures.

Equipment

Factors including:

1. Types of equipment and advantages and limitations of each type.
2. Uses, maintenance and calibration.

Application Techniques

Factors including:

1. Methods of procedure used to apply various formulations of pesticides, solutions, and gases, together with a knowledge of which technique of application to use in a given situation.
2. Relationship of discharge and placement of pesticides to proper use, unnecessary use, and misuse.
3. Prevention of drift and pesticide loss into the environment.

Laws and Regulations

Applicable state and federal laws and regulations.

Specific Standards of Competency for Each Category of Commercial Applicators

Some of the factors of this section are of particular importance because of the different types of activities carried out by applicators in each category. Such factors must be especially stressed and specifically reflected in state certification standards, as appropriate. For example, practical knowledge of drift problems should be required of agricultural applicators but not of seed treatment applicators. The latter, however, should be particularly knowledgeable of the hazards of the misuse of treated seed and the necessary precautionary techniques. Many applicators (especially public health, regulatory and demonstration and research) will have had considerable formal education, training and experience in preparation for their positions. Their competency with respect to the use and handling of pesticides will have been determined by examining boards of their professional scientific societies utilizing standards which equal or exceed those prescribed herein. Such standards should be consulted by states in developing their state standards for certification of such applicators under these regulations. Commercial applicators in each category shall be particularly qualified with respect to the practical knowledge standards elaborated below:

Agricultural Pest Control

Plant

Applicators must demonstrate practical knowledge of crops grown and the specific pests of those crops on which they may be using restricted use pesticides. The importance of such competency is amplified by the extensive areas involved, the quantities of pesticides needed, and the ultimate use of many commodities as food and feed. Practical knowledge is required concerning soil and water problems, pre-harvest intervals, re-entry intervals, phytotoxicity, and potential for environmental contamination, nontarget injury and community problems resulting from the use of restricted use pesticides in agricultural areas.

Animal

Applicators applying pesticides directly to animals must demonstrate practical knowledge of such animals and their associated pests. A practical knowledge is also required concerning specific pesticide toxicity and residue potential, since host animals will frequently be used for food. Further, the applicator must know the relative hazards associated with such factors as formulation, application techniques, age of animals, stress and extent of treatment.

Forest Pest Control

Applicators shall demonstrate practical knowledge of types of forests, forest nurseries, and seed production in their state and the pests involved. They should possess practical knowledge of the cyclic occurrence of certain pests and specific population dynamics as a basis for programming pesticide applications. A practical knowledge is required of the relative biotic agents and their vulnerability to the pesticides to be applied. Because forest stands may be large and frequently include natural aquatic habitats and harbor wildlife, the consequences of pesticide use may be difficult to assess. The applicator must therefore demonstrate practical knowledge of control methods which will minimize the possibility of secondary problems such as unintended effects on wildlife. Proper use of specialized equipment must be demonstrated, especially as it may relate to meterological factors and adjacent land use.

Ornamental and Turf Pest Control

Applicators shall demonstrate practical knowledge of pesticide problems associated with the production and maintenance of ornamental trees, shrubs, plantings, and turf, including cognizance of potential phytotoxicity due to a wide variety of plant material, drift, and persistence beyond the intended period of pest control. Because of the frequent proximity of human habitations to application activities, applicators in this category must demonstrate practical knowledge of application methods which will minimize or prevent hazards to humans, pets, and other domestic animals.

Seed Treatment

Applicators shall demonstrate practical knowledge of types of seeds that require chemical protection against pests and factors such as seed coloration, carriers, and surface active agents which influence pesticide binding and may affect germination. They must demonstrate practical knowledge of hazards associated with handling, sorting and mixing, and misuse of treated seed such as introduction of treated seed into food and feed channels, as well as proper disposal of unused treated seeds.

Aquatic Pest Control

Applicators shall demonstrate practical knowledge of the secondary effects which can be caused by improper application rates, incorrect formulations, and faulty application of restricted use pesticides used in this category. They shall demonstrate practical knowledge of various water use situations and the potential of downstream effects. Further, they must have practical knowledge concerning potential pesticide effects on plants, fish, birds, beneficial insects and other organisms which may be present in aquatic environments. These applicators shall demonstrate practical knowledge of the principles of limited area application.

Right-of-Way Pest Control

Applicators shall demonstrate practical knowledge of a wide variety of environments, since rights-of-way can traverse many different terrains, including water-ways. They shall demonstrate practical knowledge of problems on runoff, drift, and excessive foliage destruction and ability to recognize target organisms. They shall also demonstrate practical knowledge of the nature of herbicides and the need for containment of these pesticides within the right-of-way area, and the impact of their application activities in the adjacent areas and communities.

Industrial, Institutional, Structural and Health Related Pest Control

Applicators must demonstrate a practical knowledge of a wide variety of pests, including their life cycles, types of formulations appropriate for their control, and methods of application that avoid contamination of food, damage and contamination of habitat, and exposure of people and pets. Since human exposure, including babies, children, pregnant women, and elderly people, is frequently a potential problem, applicators must demonstrate practical knowledge of the specific factors which may lead to a hazardous condition, including continuous exposure in the various situations encountered in this category. Because health related pest control may involve outdoor applications, applicators must also demonstrate practical knowledge of environmental conditions, particularly related to this activity.

Public Health Pest Control

Applicators shall demonstrate practical knowledge of vector-disease transmission as it relates to and influences application programs. A wide variety of pests is involved, and it is essential that they be known and recognized, and appropriate life cycles and habitats be understood as a basis for control strategy. These applicators shall have practical knowledge of a great variety of environments ranging from streams to those conditions found in buildings. They should also have practical knowledge of the importance and employment of such non-chemical methods as sanitation, waste disposal, and drainage.

Regulatory Pest Control

Applicators shall demonstrate practical knowledge of regulated pests, applicable laws relating to quarantine and other regulation of pests, and the potential impact on the environment of restricted use pesticides used in suppression and eradication programs. They shall demonstrate knowledge of factors influencing introduction, spread, and population dynamics of relevant pests. Their knowledge shall extend beyond that required by their immediate duties, since their services are frequently required in other areas of the country where emergency measures are invoked to control regulated pests and where individual judgments must be made in new situations.

Demonstration and Research Pest Control

Persons demonstrating the safe and effective use of pesticides to other applicators and the public will be expected to meet comprehensive standards reflecting a broad spectrum of pesticide uses. Many different pest problem situations will be encountered in the course of activities associated with demonstration, and practical knowledge of problems, pests, and population levels occurring in each demonstration situation is required. Further, they should demonstrate an understanding of pesticide-organism interactions and the importance of integrating pesticide use with other control methods. In general, it would be expected that applicators doing demonstration pest control work possess a practical knowledge of all of the standards detailed in section 171.4(b) (Federal Register. Vol. 3g, No. 197). In addition, they shall meet the specific standards required for the first 7 categories of this section as may be applicable to their particular activity. Persons conducting field research or method improvement work with restricted use pesticides should be expected to know the general standards detailed in 171.4(b). In addition, they shall be expected to know the specific standards required for the first 9 categories of this section, applicable to their particular activity, or alternatively, to meet the more inclusive requirements listed under "Demonstration".

The Above Standards Do Not Apply To the Following Persons For Purposes of These Regulations

1. Persons conducting laboratory type research involving restricted use pesticides; and
2. Doctors of Medicine and Doctors of Veterinary Medicine applying pesticides as drugs or medication during the course of their normal practice.

Standards for Certification Of Private Applicators

1. Competence in the use and handling of pesticides by a private applicator will be determined by procedures set forth below. State standards must comform and be at least equal to those prescribed herein. As a minimum requirement for certification, a private applicator must show that he possesses a practical knowledge of the pest problems and pest control practices associated with his agricultural operations; proper storage, use, handling and disposal of the pesticides and containers; and his related legal responsibility. This practical knowledge includes ability to:
   a. Recognize common pests to be controlled and damage caused by them.
   b. Read and understand the label and labeling information–including the common name of pesticides he applied; pest(s) to be controlled, timing and methods of application; safety precautions; any pre-harvest or re-entry restrictions; and any specific disposal procedures.
   c. Apply pesticides in accordance with label instructions and warnings, including the ability to prepare the proper concentration of pesticide to be used under particular circumstances taking into account such factors as area to be covered, speed at which application equipment will be driven, and the quantity dispersed in a given period of operation.
   d. Recognize local environmental situations that must be considered during application to avoid contamination.
   e. Recognize poisoning symptoms and procedures to follow in case of a pesticide accident.

Such competence of each private applicator shall be verified by the responsible State agency through the administration of a private applicator certification system which ensures that the private applicator is competent, based upon the standards set forth above, to use the restricted use pesticides under limitations of applicable state and federal laws and regulations. A certification system shall employ a written or oral testing procedure, or such other equivalent system as may be approved as part of a state plan.

1. In any case where a person, at the time of testing for certification, is unable to read a label, the responsible State agency may employ a testing procedure, previously approved by the Administrator, which can adequately assess the competence of such person with regard to all of the above standards. Certification must be related and limited to the use and handling of each individual pesticide for which he desires certification at any time. Therefore, the applicator will be authorized to use only the pesticide(s) for which he has demonstrated competence.
2. A specific procedure is required (171.5a) relating to label comprehension, with testing designed to assure his knowledge of the following:
   a. Understanding of the label and labeling information including those items indicated in that subsection.
   b. Sources of advice and guidance necessary for the safe and proper use of each pesticide related to his certification.

Standards for Supervision of Non-Certified Applicators by Certified Private and Commercial Applicators

Certified applicators whose activities indicate a supervisory role must demonstrate a practical knowledge of federal and state supervisory requirements, including labeling, regarding the application of restricted use pesticides by non-certified applicators.

The availability of the certified applicator must be directly related to the hazard of the situation. In many situations, where the certified applicator is not required to be physically present, "direct supervision" shall include verifiable instruction to the competent persons, as follows:

1. Detailed guidance for applying the pesticide properly, and
2. Provisions for contacting the certified applicator in the event he is needed.

In other situations, and as required by the label, the actual physical presence of a certified applicator may be required when application is made by a non-certified applicator.

TERMS

a. The term "accident" means an unexpected, undesirable event, caused by the use or presence of a pesticide, that adversely affects man or the environment.

b. The term "Act" means the Federal Insecticide, Fungicide, and Rodenticide Act, as amended (86 Stat. 973), and other legislation supplementary thereto and amendatory thereof.

c. The term "Administrator" means the Administrator of the Environmental Protection Agency, or any office or employee of the Agency to whom authority has heretofore been delegated, or to whom authority may hereafter be delegated, to act in his stead.

d. The term "Agency," unless otherwise specified, means the United States Environmental Protection Agency.

e. The term "agricultural commodity" means any plant, or part thereof, or aminal, or animal product, produced by a person (including farmers, ranchers, vineyardists, plant propagators, Christmas tree growers, aquaculturists, floriculturists, orchardists, foresters, or other comparable persons) primarily for sale, consumption, propagation, or other use by man or animals.

f. The term "calibration of equipment" means measurement of dispersal or output of application equipment and adjustment of such equipment to control the rate of dispersal, and droplet or particle size of a pesticide dispersed by the equipment.

g. The term "certification" means the recognition by a certifying agency that a person is competent and thus authorized to use or supervise the use of restricted use pesticides.

h. The term "certified applicator" means any individual who is certified to use or supervise the use of any restricted use pesticides covered by his certification.

i. The term "commercial applicator" means a certified applicator (whether or not he is a private applicator with respect to some uses) who uses or supervises the use of any pesticide which is classified for restricted use for any purpose or on any property other than as provided by the definition of "private applicator."

j. The term "compatibility" means that property of a pesticide which permits its use with other chemicals without undesirable results being caused by the combination.

k. The term "competent" means properly qualified to perform functions associated with pesticide application, the degree of capability required being directly related to the nature of the activity and the associated responsibility.

l. The term "common exposure route" means a likely way (oral, dermal, respiratory) by which a pesticide may reach and/or enter an organism.

m. The term "environment" means water, air, land, and all plants and man and other animals living therein, and the interrelationships which exist among them.

n. The term "forest" means a concentration of trees and related vegetation in non-urban areas sparsely inhabited by and infrequently used by humans; characterized by natural terrain and drainage patterns.

o. The term "hazard" means a probability that a given pesticide will have an adverse effect on man or the environment in a given situation, the relative likelihood of danger or ill effect being dependent on a number of interrelated factors present at any given time.

p. The term "host" means any plant or animal on or in which another lives for nourishment, development, or protection.

q. The term "non-target organism" means a plant or animal other than the one against which the pesticide is applied.

r. The term "ornamental" means trees, shrubs, and other plantings in and around habitations generally, but not necessarily located in urban and suburban areas, including residences, parks, streets, retail outlets, industrial and institutional buildings.

s. The term "practical knowledge" means the possession of pertinent facts and comprehension together with the ability to use them in dealing with specific problems and situations.

t. The term "private applicator" means a certified applicator who uses or supervises the use of any pesticide which is classified for restricted use for purposes of producing any agricultural commodity on property owned or rented by him or his employer or (if applied without compensation other than trading of personal services between producers of agricultural commodities) on the property of another person.

u. The term "protective equipment" means clothing or any other materials or devices that shield against unintended exposure to pesticides.

v. The term "regulated pest" means a specific organism considered by a state or federal agency to be a pest requiring regulatory restrictions, regulations, or control procedures in order to protect the host, man and/or his environment.

w. The term "restricted use pesticide" means a pesticide that is classified for restricted use under the provisions of section 3(d) (1) (C) of the Act.

x. The term "standard" means the measure of knowledge and ability which must be demonstrated as a requirement for certification.

y. The term "State" means a State, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, the Trust Territory of the Pacific Islands, and American Samoa.

z. The term "susceptibility" means the degree to which an organism is affected by a pesticide at a particular level of exposure.

aa. The term "toxicity" means the property of a pesticide to cause any adverse psychological effects.

bb. The term "under the direct supervision of" means the act or process whereby the application of a pesticide is made by a competent person acting under the instructions and control of a certified applicator who is responsible for the actions of that person, and who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is applied.

PROPOSED REGULATIONS FOR PROHIBITION OF CERTAIN ACTS REGARDING DISPOSAL AND STORAGE

Pesticides and Pesticide Containers

The Federal Insecticide, Fungicide and Rodenticide Act, as amended by the Federal Environmental Pesticide Control Act of 1972 (FIFRA, as amended) (86 Stat. 973, PL 92-516) requires the Administrator of the U.S. Environmental Protection Agency (the Agency) to establish regulations and procedures for the disposal and storage of pesticides and their containers.

While the basic thrust of the FIFRA, as amended, is to regulate the registration, labeling, and application of pesticides, a primary goal of the Act is the "protection of health and the environment," which is defined to mean "protection against any unreasonable adverse effects on the environment." The Agency has determined that some methods of pesticide disposal and storage are so likely to cause unreasonable adverse effects on health or the environment that the best form of regulation is to prohibit such acts. These worst acts include open burning (unless undertaken by the user in small quantities in open fields), open dumping, water dumping (except as may be provided for by regulations issued pursuant to sections 304, 307, 311, 402, and 404 of the Federal Water Pollution Control Act Amendments of 1972), ocean dumping (except as may be permitted by regulations developed under the Marine Protection, Research, and Sanctuaries Act of 1972), storage in such a manner as to cause contamination of food or feed supplies, and well injection without adequate testing to assure environmental protection.

DEFINITIONS

As used in this part, all terms not defined herein shall have the meaning given them by the Act and by prior publication of Regulations and Recommended Procedures on May 1, 1974, in the Federal Register (Vol. 39, No. 85, Part IV, P. 15237) for this part.

1. "Dilutent" means the material added to a pesticide or a pesticide-related waste by the user or manufacturer to reduce the concentration of active ingredient.
2. "Ocean dumping" means the disposal of pesticides, pesticide containers, or pesticide-related wastes in or on the oceans and seas as defined in PL 92-532.
3. "Open burning" means the combustion of a pesticide, pesticide container, or pesticide-related waste in any fashion other than by incineration in a pesticide incinerator.
4. "Open dumping" means the placing of pesticides, pesticide containers, or pesticide-related waste in a land site in a manner which does not protect the environment and is exposed to the elements, vectors, and scavengers.
5. "Pesticide-related wastes" means all pesticide-containing manufacturing or processing wastes or pesticide-containing by-products which are to be discarded, but which, pursuant to acceptable pesticide, manufacturing or processing operations, are not ordinarily a part of or contained within an industrial waste stream discharged into a sewer or the waters of a State.
6. "Soil injection" means the emplacement of pesticides or pesticide-related wastes by ordinary tillage practices within the plow layer of a soil.
7. "Water dumping" means the disposal of pesticides or pesticide-related wastes in or on lakes, ponds, rivers, sewers, or other water systems as defined in PL 92-500.

AUTHORIZATION AND SCOPE

The regulations promulgated under Subpart C, Section 165.7 are those deemed necessary by the Administrator to prohibit the worst acts of pesticide storage and disposal. Said regulations are published pursuant to section 19(a) and 25(a) of the Act which authorize the Administrator to promulgate procedures and regulations for the disposal and storage of pesticides, pesticide containers, and excess amounts of pesticides. The authority to enforce the regulations under Subpart C, section 165.7 is derived from section 14 of the Act which provides for the imposition of civil or criminal penalties for violations of the provisions of the Act. In addition, section 12(a)(2)(G) makes it unlawful to use a pesticide in a manner inconsistent with its labeling. Disposal or storage of a pesticide in a manner inconsistent with the instructions on the labeling will therefore constitute a specific unlawful act, subject to civil or criminal penalties. These regulations shall apply to all users, producers, or distributors or pesticides, pesticide containers, and pesticide-related wastes.

PROHIBITED PROCEDURES

1. Open dumping. No pesticide, pesticide-related waste, pesticide container, or residues from a pesticide container shall be disposed of in such a manner as to cause or allow open dumping, as defined by section 165.1(o).
2. Open burning. No pesticide, pesticide-related waste, pesticide containers, or residue from a pesticide container shall be disposed of in such manner as to cause or allow open burning, as defined by section 165.1(n). Small quantities of combustible containers, not to exceed 50 lbs, or the quantity emptied in a single work day, which is less (except those formerly containing organic forms of beryllium, selenium, mercury, lead, cadmium, or

arsenic), may be burned by the applicator in open fields where (a) due regard is given to wind direction in relation to receptors such as population centers, crops susceptible to pesticide vapors, field workers, domestic animals, and surface water supplies, (b) such open burning is consistent with Federal, State, or local ordinances, and (c) provisions are made to avoid contamination of surface and groundwater.

3. Water dumping. No pesticide, pesticide-related waste, pesticide container, or residue from pesticide container shall be stored or disposed of in such manner as to cause or allow water dumping, as defined by section 165.1(z), or ocean dumping, as defined by section 165.1(m), except in conformance with regulation developed pursuant to the Marine Protection, Research, and Sanctuaries Act of 1972 (PL 92-532), and to Sections 304, 307, 311, 402, and 404 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500).
4. Contamination of food and feed supplies. No pesticide or pesticide-related waste that is classified as highly toxic or moderately toxic and is required to bear the corresponding signal words on the label, pesticide container, or residue from a pesticide container shall be disposed of or stored in proximity to and in such manner as to cause or allow direct exposure which may result in contamination of food or feed, or food or feed packaging materials.
5. Well injection.
   a. No pesticide, pesticide-related waste, pesticide container, or residue from a pesticide container shall be disposed of by well injection unless the person(s) proposing to undertake such disposal first receives approval from the appropriate State agency, demonstrates that he has exhausted all reasonable alternative methods of disposal and finds them unsatisfactory in terms of environmental considerations, submits to the Regional Administrator in the Region where the well is to be located the recommended data requirements which accompany ADS No. 5 (Federal Register, Vol. 39, No. 69, April 9, 1974), and obtains the approval of the Regional Administrator for the proposed well injection. Included in these information requirements are:
      i. The location and design of the injection well;
      ii. The type and amount of pesticide to be injected;
      iii. The results of pre-injection tests made to predict the fate of materials injected;
      iv. Provisions for monitoring the operation and the effects on the environment;
      v. Provisions for plugging injection wells when abandoned;
      vi. Contingency provisions for coping with injection well failures.
   b. If spills from storage containers, or from the injection operation occur, disposers are warned of their potential liability and penalties which may be imposed under Section 311 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500).
   c. If at any time after approval of an application for the well injection of a pesticide there is additional information regarding adverse effects on the environment, such information shall be submitted to the aforementioned Regional Administrator.

SUGGESTED REFERENCES

Williams-Steiger. Occupational Health and Safety Act–1970.

Federal Insecticide, Fungicide and Rodenticide Act as Amended 1972.

Federal Register, October 9, 1974–Vol. 39, Number 197.

Federal Register. October 16, 1974–Vol. 39, Number 201.

Federal Register. October 15, 1974–Vol. 39, Number 200.

STATE LAWS & REGULATIONS

Brief Synopsis of the Arizona Statutes Rules and Regulations

No person, partnership, corporation or association shall engage in the business of Structural Pest Control without being licensed by a Structural Pest Control Board.

Structural Pest Control is defined as control of household pest, wood-destroying pests or organisms, or other pests which may invade households or other structures, including railroad cars, boats, docks, trucks, airplanes or the contents thereof, or pests including weeds, which exist in the area around structures, in lawns or ornamental shrubs and trees.

A license must be possessed to make identifications of infestations or infections, offering to engage in pest control, advertising or soliciting to perform pest control. A license must also be possessed to make inspection reports, recommendations, estimates and/or bids, whether written or oral or for the purpose of submitting bids for the use of insecticides, pesticides, rodenticides, fumigants, herbicides or allied substances including mechanical devices for the purpose of controlling or preventing infestations or infections of any pest in or around structures.

The Board is composed of 5 members, 2 must represent the public and be well versed in structural pest control practices or allied fields. The other 3 must have been in the pest control practice, in Arizona, for at least the past 5 years. A member is appointed each year by the Governor for a term of 5 years; however, no member may serve more than 2 consecutive terms. A majority of the Board consitutes a quorum; however, at least 1 member of such quorum must be a member representing the public. All Board meetings are open to the public except executive sessions.

The Board has the power to cause or make investigations, compel attendance, administer oaths and take testimony concerning all matters within its jurisdiction. The Board may adopt reasonable rules and regulations necessary to carry out its duties under the Statutes.

The maximum fees are as follows: application or examination for registration, $100; registration or annual renewal, $100.

Persons not required to be licensed

1. Those engaged only in agriculture pest control work and licensed or supervised by the Board of Pest Control Applicators;
2. Those that perform pest control on property which they own, lease or rent;
3. Governmental Agencies, State, Feder City or County officials when officia engaged;
4. Any educational institution or State agen engaged in research or study of pe control.

Applications for examination or licens must be on forms as prescribed by the Boar and must contains not less than the name and address of the applicant. If the applicant for license is a partnership, corporation or association, the name of the responsible person to be licensed on behalf of such entity must be on the application. Should the responsible person of any firm or entity become disassociated with the Arizona operation of said firm or entity for any reason, the firm or entity has 90 days from such disassociation to make application for the licensing of another responsible person.

Each applicant must satisfy the Board of his character, responsibility, good faith and that he is qualified to carry out the business of structural pest control.

The Board may by examination, oral or written, determine the individuals knowledge of structural pest control and his knowledge of the use, storage and application of chemicals and other devices used in the field of pest control.

Examination and license may be applied for in one or any combination or all of the following classifications:

1. General Pest Control;
2. Control of Wood-Destroying Organisms;
3. Weed Control;
4. Fumigation.

The Board by rule may establish other classifications. All licenses are issued for a calendar year and are renewable annually. There are no provisions for a temporary license or work permit.

All licensed entities must furnish the Board with financial proof protecting persons who may suffer legal damages as a result of the pest control operations of the licensee. Financial proof may consist of either a deposit of money, liability insurance, surety bond or certified check and the amount of such financial responsibility shall not be less than $25,000 for property damage, and a like amount for public liability.

The Board may revoke, suspend or refuse to renew any license if the Board finds the licensee has committed any of the following acts:

1. Operating a business in a faulty, careless or negligent manner.
2. Refusing or neglecting to comply with the Law, Rules and Regulation or any lawful

order of the Board.

3. Making false or fraudulent records or report.
4. Misrepresentation by the applicant in obtaining a license.
5. Willful failure to fulfill the terms of a contract or agreement.
6. Commission of any grossly negligent or fraudulant act while engaged in the pest control business.
7. Negligent handling or use of any chemical or device without due respect to public safety.
8. Making any false statements, or misrepresentations concerning his business through any material.
9. Conviction of a felony or misdemeanor in connection with the operation of his business.
10. Adjudication of bankruptcy.

Violations of the statute is considered a misdemeanor punishable by a fine of not more than $300, by imprisonment in the County Jail not to exceed 60 days or both.

Licensees must, in the course of their business, use the name as licensed. A license may be associated with only one business entity at one time. Licenses are not transferable and only can be legally used by the person to whom it is issued.

Each licensee must make and preserve reasonable records for a period of 2 years of work performed. Whenever there is any representation of wood-destroying pests in existing structures, the record must consist of not less than a written description stating the nature and location of any infestation and/or damage.

When a licensee changes his business or residence location he must notify, by registered or certified mail, of such change within 10 days. If a license is included in a civil or criminal suit or complaint as a result of his pest control operation, he must notify the Board, by certified or registered mail, the nature of such suit or complaint within 10 days from receipt of notice of such suit or complaint.

All vehicles, other than management vehicles not used exclusively in selling or soliciting pest control work, must be identified on both sides of the vehicle; showing the licensed name, license number and category. Such identification must be prominently displayed in contrasting color to background color in letters and numerals not less than 2 inches in height.

Except in tanks, from which it will be directly discharged, all chemicals on vehicles must be kept under lock and key. Yard or office storage facilities of chemicals must be in compliance with all political subdivisions building and zoning requirements.

Wood infestation reports used for the purpose of real estate transfer or sale must contain at a minimum the information as shown by form on page 21 (October, 1974 issue).

Fumigation must be done while a person fully competent is present. Proper and effective gas mask must be available on the job. Each side of each building and entrance or exit way must have fumigant warning signs posted. Each building must be inspected for the presence of humans or domestic pets prior to injection of fumigant. A licensee may not use or possess any fumigant unless he in fact is licensed to do fumigation.

All pest control must be done under the supervision of the person licensed by the Board. "Supervision" means that a pesticide is applied by a competent person acting under the instructions and control of a licensed person who is available if and when needed, even though such licensed person is not physically present at the time and place the pesticide is applied.

Supplementary Synopsis of Arizona State Law

"Act" means the Federal Environmental Pesticide Control Act of 1972 and "Administrator" means the head of the Environmental Protection Agency of the United States.

A "Restricted Use Pesticide" is one that has been defined as having the properties that may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator.

"Structural Commercial Applicator" is a person who uses or supervises the use of any restricted use pesticide.

"Under the direct supervision of" means that, unless otherwise prescribed by the label of a particular pesticide, a pesticide is applied by a competent person acting under the instructions and control of a certified applicator who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is applied.

"Unreasonable adverse effects on the environment" means any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide.

The Board may adopt Rules and Regulations which shall include, but are not limited to:

1. Categorization of applicators for certification
2. Standards for certification of applicators within the various categories
3. Standards for supervision on non-certified applicators by certified Structural commercial applicators
4. Requirements that applicators keep records.

The Board may investigate alleged violations of the Act, State Law, Rules and Regulations or its orders or any of the Rules and Regulations promulgated by the Environmental Protection Agency.

The Board may require examinations and other demonstrations of competence prior to certification.

The Board may enter into cooperative agreement with Federal and/or State agencies for the purpose of certification and enforcement of the State Program.

After October 21, 1976, no one may apply a restricted pesticide unless that person is certified or acting under the direct supervision of a certified person.

Certification of applicants will be done by the Board and each certification is for a period of one year and each certification may be renewed yearly.

The Board has the power to refuse certification, revoke or suspend certification for reason or cause which may be, but are not limited to the following:

1. Violation of any of the provisions of the Act or any of its Rules and Regulations.
2. Violation of any of the Rules and Regulations of the Board.
3. Violation of any condition imposed by the Board in connection with a certification.

Violations, civil penalty, are punishable by a fine not to exceed $1,000. Violations, criminal penalty, not more than $300 or imprisoned for not more than 6 months, or both.

Injunctions for violation of any Article or Rule, Regulation or order of the Board may be sought and issued upon any firm found guilty of such violation.

The Board or any of its duly authorized agents may enter with warrant, any private or public property where it has reason to believe any restricted use pesticides are being used or stored, for the purpose of inspecting and investigating conditions relating to the use and application of restricted pesticides.

LEARNING AT HOME

Review Questions – Section 10

1. Tolerances for residues on foodstuff are established by ______.
2. A restricted use pesticide is one which ______

   ____
3. If you violate FEPCA unintentionally, you may be fined ______.
4. State standards for the determination of competency must ______________

   ____

   to those adopted by E.P.A.
5. List at least 4 areas of competency in the comprehension of labels that commercial applicators must demonstrate a practical knowledge of:
   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________
6. List at least 3 things that an applicator must demonstrate a practical knowledge of in the area of safety:
   1. ______________________________
   2. ______________________________
   3. ______________________________
7. List at least 4 things pertaining to the potential environmental consequences of the use and misuse of pesticides, that an applicator must have knowledge of:
   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________
8. List at least 5 things that an applicator should know about pesticides in order to determine competency:
   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________
   5. ______________________________
9. In order to determine competency, what are the 3 main areas in the knowledge of pests that an applicator should have:
   1. ______________________________
   2. ______________________________
   3. ______________________________
10. Supervision of a non-certified applicator by a certified applicator shall include:

    ____

    ____

    ____

    ____
11. The term "calibration of equipment" means: ______________________________

    ____
12. The term "compatibility" means:

    ____

    ____
13. The term "environment" means:

    ____

    ____
14. What is meant by the term "toxicity":

    ____

    ____
15. The term "practical knowledge" means:

    ____

    ____

OUTSIDE ASSIGNMENTS

Obtain copies of all Federal and Local Laws affecting the use of pesticides. Study them and make your own list of everything that might apply to your day to day activities. Try and obtain a list of all dumps in your area that will accept pesticide wastes and containers. Be sure and check into what warning signs you should use in transporting and storing of pesticides.

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ARIZONA POISON CONTROL CENTERS*

CITY	Name and Address	Telephone
STATE COORDINATOR...	Albert L Picchioni, Ph.D. Professor of Pharmacology College of Pharmacy University of Arizona Tucson AZ 85721	884-1587 884-1428
Douglas.......	Poison Control Center Cochise County Hospital Rural Route #1 85607	364-7931
Flagstaff.....	Poison Control Center Flagstaff Hospital 1215 North Beaver Street 86001	774-5233 Ext. 255
Ganado........	Poison Control Center Project Hope Sage Memorial Hospital Box 457 86505	755-3411
Kingman.......	Poison Control Center Mohave General Hospital 3269 Stockton Hill Road Kingman AZ 86401	757-2101 Ext. 245, 247
Nogales.......	Poison Control Center St. Joseph's Hospital Target Range Road P.O. Box 1809 85621	287-2771 Ext. 94
Phoenix.......	Poison Control Center Good Samaritan Hospital 1033 E McDowell Road 85006	252- 6611 Ext. 3711, 12, 3713
	Poison Control Center Maricopa County General Hospital 2601 E Roosevelt 85008	267-5411
	Poison Control Center Memorial Hospital 1200 S 5th Avenue 85003	252-5911 Ext. 391
	Poison Control Center St. Joseph's Hospital 350 W Thomas Road 85013	277-6611 Ext 3581

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* Poison control centers as listed in the Directory of Poison Control Centers, Bureau of Product Safety, Division of Hazardous Substances and Poison Control,

City	Name and Address	Telephone
Phoenix--continued		
	Poison Control Center St. Luke's Hospital Medical Center 525 N 18th Street 85006	258-7373 Ext. 291
Prescott......	Poison Control Center Yavapai Community Hospital 1003 Willow Creek Road 86301	445-2700 Ext. 25
Tucson........	Arizona Poison Control Information Center College of Pharmacy University of Arizona 85721	882-6300
	Poison Control Center Pima County General Hospital 2900 S 6th Avenue 85713	792-8335
	Poison Control Center St. Mary's Hospital 1700 W St. Mary's Road 85703	622-5833 Ext 625 and 626
	Poison Control Center Tucson General Hospital 3838 N Campbell Tucson, AZ 85719	327-5431
	Poison Control Center Tucson Medical Center E. Grant Road at Beverly Blvd 85716	327-5461 Ext. 482
Winslow.......	Poison Control Center Winslow Memorial Hospital 116 E Hillview St 86047	289-4691
Yuma..........	Poison Control Center Yuma Regional Medical Center Avenue A and 24th St. 85364	344-2000 Ext. 221

Licensing, Permits and Certification Facts for Commercial Pesticide Applicators in Arizona

Anyone applying pesticides commercially in Arizona must have a valid applicator's *license*. For those who use Environmental Protection Agency (EPA) or Arizona "restricted use" pesticides, an additional *certification* is required.

The type of license an applicator must have depends entirely upon where the pesticides are applied. If a chemical is used in an **agricultural** situation, the license is obtained from the **Board of Pesticide Control**. Should the pesticide be used for pest control in the **urban** or **structural** area, the license is issued by the **Structural Pest Control Board.**

Licensing for agricultural uses

The Board of Pesticide Control issues agricultural commercial licenses to those individuals who pass a written examination demonstrating their familiarity with the dangers of, and the safety precautions to take while handling and using pesticide products. The license costs $100 and is good for one calendar year. *Re-examination is required every odd year thereafter.* Before the Board issues the license, however, the applicant must furnish proof of financial responsibility by either depositing money, liability insurance, surety bond or certified check in amounts *not less than* $25,000 for property damage, $25,000 public liability and $25,000 drift insurance.

The Board licenses the applicator's equipment, as well. Each piece of aerial or ground-operated custom application equipment costs $25 a year to license.

Additionally, the Board licenses Agricultural Pest Control Advisors. These advisors make written recommendations for the control of agricultural pest situations. To qualify for a license, applicants must complete an application form, pass a written test on pesticide use, safety, law, rules and regulations and pay a $25 fee. The applicant also must pass the test in one or more of these *specific* categories:

- control of insects, mites, other invertebrates
- control of plant pathogens
- control of nematodes
- control of vertebrate pests
- control of weeds
- defoliants and plant growth regulators.

The Pest Control Advisors' License is renewed annually for $25. *If not renewed by January 1st, there is an additional late-registration fee of $10.*

The Board also has the duty of issuing permits to growers and sellers who use agricultural pesticides. The **grower's** permit ($20 a year) allows a grower to apply pesticides, or have them applied "to properties which the grower owns, rents or leases." The **seller's** permit ($100 a year) allows agricultural chemical business people, or listed field personnel, to sell pesticides to growers or applicators in Arizona.

For further information on the Board's rules, responsibilities and activities, contact

BOARD OF PESTICIDE CONTROL
2538 E. University Drive, Suite 135
Phoenix, Arizona 85034
(602) 271-3578

Licensing for urban and structural uses

The Structural Pest Control Board deals exclusively with licensing and regulating pesticide use in urban and structural areas. To be licensed by this Board, the applicant must complete an application form (furnished by the Board) and return it with a $100 registration fee and two letters of personal recommendation.

The applicant must pass a test in one or more areas of specialization from five categories:

- general pest control
- wood destroying insects and organisms
- weed control
- fumigation
- control of horticultural pests.

The applicator will be notified within 30 days, by mail, of the test results. A passing mark is 70 percent *in all sections taken.* If necessary, any failed sections may be rescheduled immediately. After two unsuccessful attempts, however, the candidate is assumed to have failed and must wait 90 days to submit another $100 application fee. At that time, retesting can be scheduled.

After the applicant has passed the test, the Board publishes an *intent to license,* and waits 20 days for any objections to be filed. If none are raised, the applicant then pays the $100 license fee and submits proof of financial responsibility consisting of either a deposit of money, insurance, surety bond or certified check of *not less than* $25,000 for property damage and $25,000 for personal liability. The applicant then receives a license to operate **only** in those areas of original, successful testing.

The *active* applicator's license is valid until the end of the calendar year. It must be renewed (renewal fee of $100) *before* December 31st. Renewal during January of the following year will cost $200 ($100 renewal fee *plus* $100 delinquent fee). If the license is not renewed before February 1st, it is considered lapsed and the applicator must begin again as a new applicant.

A $25 (annually renewable) *inactive* license is available from the Board for those who have passed the examination but are not actively engaged in pest control. *The delinquent fees are 100 percent if not renewed by December 31st.*

For further information on this Board's rules, responsibilities and activities, contact

STRUCTURAL PEST CONTROL BOARD
2207 South 48th Street, Suite M
Tempe, Arizona 85282
(602) 271-3664

"Restricted use" certification

The two Boards also have *certification* responsibilities authorized by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) as amended in 1972 and 1975. The law requires that anyone using the EPA (or Arizona) "restricted pesticide products" shall be *certified,* which requires passing a written examination on the safe and effective use of pesticide products in situations particular to the applicator's chosen field.

The applicant must show competency in eight general (core exam) areas:

- label/labeling comprehension
- safety
- environment
- pests
- pesticides
- application techniques
- application equipment
- laws and regulations

After successfully completing the core examination, applicants must demonstrate competency through testing in at least one of these specialty areas:

- agricultural
- aquatic
- forest
- industrial
- institutional
- ornamental and turf
- right-of-way
- seed treatment
- health related or public health

Agricultural certification

For policy and fees concerning certification for "restricted use" chemicals in an agricultural situation, contact the Board of Pesticide Control.

Urban and structural certification

After passing the complete examination, the certified applicator may use or supervise the use of restricted pesticides in urban and structural pest control programs. The initial fee is $15 (which covers examination and first year certification). Thereafter, there is a renewal fee of $5 and a new identification card charge of $1.50 annually.

Licensed applicators who do not use restricted chemicals, but rely entirely on general use products in pest control programs, do not have to be certified. However, questions about the necessity for any particular person to be certified should be directed to the responsible Board.

LICENSING AND CERTIFICATION IN ARIZONA

Board of Pesticide Control

(Licensing)

1. Agricultural Pest Control Advisors
   ($25 initial; *$25 renewal)*
2. Agricultural Pesticide Applicators
   ($100 initial; *$100 renewal)*
3. Custom Application Equipment — single piece ($25 initial; *$25 renewal)*

(Permits)

1. Growers
   ($20 initial; *$20 renewal)*
2. Sellers
   ($100 initial; *$100 renewal)*

(Certification)

(Contact the Board directly)

Structural Pest Control Board

(Licensing)

1. Registration fee: $100
2. License fee (active)
   ($100 initial, *$100 renewal)*
3. License fee (inactive)
   ($25 initial; *$25 renewal)*

(Certification)

1. Urban and Structural Pest Control Applicators ($15 initial; *$5 renewal and $1.50 ID card)*